Neely Nature Notes

June 2006 — September 2009

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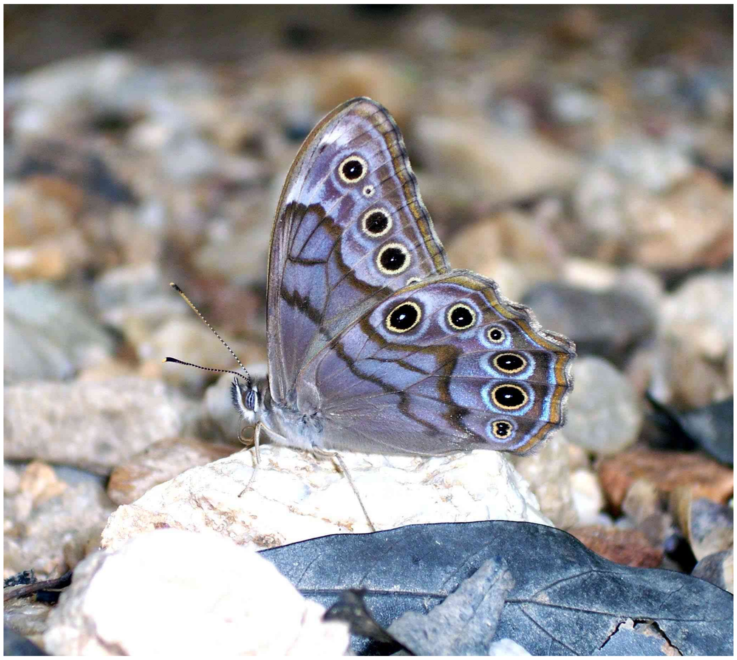
This is a compilation of 34 short articles published between June of 2006 and September of 2009 in the *Neely Farm Chronicle*, a neighborhood newletter in Greenville County, South Carolina. Missing text has been added to two articles, one dealing with "Bess Bugs" and the other with "Turtles." In all other cases the original text is shown. In some cases new photographs or captions have been added, or the original photograph has been replaced. All written articles are released for general use and distribution, subject to a Creative Commons Attribution Share-Alike 3.0 Unported License. For each article, the original date of production, and the month of publication (in parentheses) are given. Articles published in July appeared in a combined July—August issue of the Neely Farm Chronicle, while those published in December appeared in a combined December—January issue. Two separate articles were published in October of 2006.

Monday, May 15, 2006 (June 2006)

The Creole Pearly Eye Butterfly

The Creole Pearly Eye (*Enodia creola*) is considered to be either rare or uncommon in the Carolinas, but can be observed in the woods near Rocky Creek here in Neely Farm. The first generation emerges in April each year, after the over-wintering caterpillars complete their pupation. The third generation is active through September. This species can be found in dense swamp forests throughout the Southeast, but not in Southern Georgia or Florida. Wingspan is about 2 ½" or 6.5 cm.



Creole Pearly Eye (*Enodia creola*) on gravel near the edge of Rocky Creek, in Neely Farm , South Carolina.

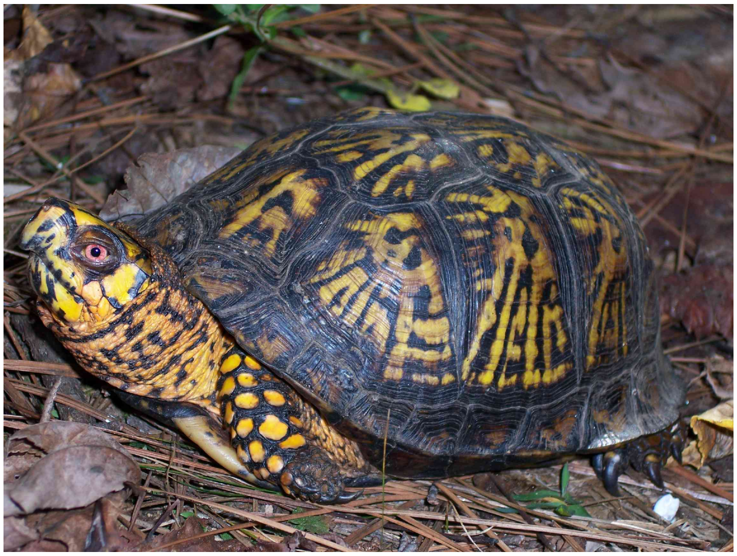
You may think that all insects have six legs. Like other "nymphalid" butterflies, Pearly Eyes have only four legs! The first pair is reduced, and cannot be used for walking. Unlike many other butterflies, Pearly Eyes may be active at dusk or even at night, and they do not take nectar from flowers. Instead, they frequent wet sand, or tree sap sites. They also collect essential salts from dry gravel or animal droppings along Rocky Creek.

Caterpillars hide during the day and feed at night on our native bamboo (*Arundaria gigantea*, variety *tecta*), also found here along Rocky Creek. This bamboo is also known as Switch Grass.

Pearly Eyes rest with their wings closed, so that the "eye" spots under the wings are readily visible. These spots are thought to confuse or frighten predators. When you are ready to explore nature a little, go out into the woods around the soccer field or your back yard and try to find this little guy!

Thursday, June 15, 2006 (July/August 2006)

Our Pond and Woodland Turtles


Adult Eastern Box Turtle (*Terrapena carolina*) resting on a forest path in Neely Farm. This is our most terrestrial turtle.

Turtles are ancient creatures, but not as remotely related to other reptiles as was once thought. Because of their rather solid ("anapsid") skulls, they were once thought to represent a primitive group of reptiles that preceded the "diapsid" (with skull bearing *two* large openings on the side) lizards, snakes, crocodylians, dinosaurs, and birds, perhaps more closely related to ancestral mammals. We now know that they are part of the diapsid group, and that their solid, armored skull evolved along with the rest of their protective body armor.

As armored creatures, turtles rely more on concealment and armor than on speed to evade their predators. Our native Eastern Box Turtle can even move anterior and posterior (front and back) plates of its plastron to completely conceal its head and legs, thus deterring all but the most persistent woodland racoons from doing it major harm. Other turtles in our area generally cannot close their shells like this, but they will withdraw their head and legs into the shell if threatened.

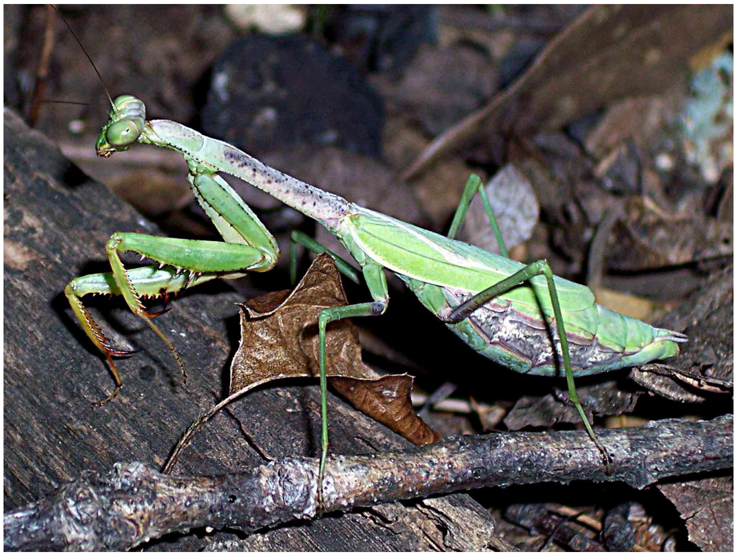
The Southeastern United States is one of the "hotbeds" of turtle diversity. There are six different groups of turtles in South Carolina: the Gopher Tortoise (Low Country near Georgia border), the pond turtles (including the Box Turtle, pond turtles that are frequently seen in ponds and along streams, and the Diamondback Terrapin of coastal salt marshes), the large softshell turtles found buried in the sandy bottoms of our streams, the large Common Snapping Turtle, the small musk and mud turtles, and the sea turtles (including the massive Loggerhead Turtles that nest on our coasts). Two species of very small (less than 5") pond turtles found in South Carolina are rare and seldom encountered. These are the rare Spotted Turtle (*Clemmys guttata*) of the Midlands to Low Country, and the even rarer Bog Turtle (*Glyptemys muhlenbergii*) of the Upstate. The Common Snapping Turtle (*Chelydra serpentina*), the Eastern Mud Turtle (*Kinosternon subrubrum*), and the Common Musk Turtle (*Sternotherus odoratus*) are common all over the state, but are seldom seen because they usually stay near the bottom of ponds, and bask infrequently. They are here, nonetheless.

The turtles that you are most likely to encounter are the two species of pond turtles that inhabit our local fishing pond. These are the larger Yellow-bellied Slider (*Trachemys scripta*) and the smaller Eastern Painted Turtle (*Chrysemys picta*). Most of our local Sliders have bright yellow patches on the sides of the head, particularly when young. However, there are some "Red-eared" Slider genes in the area as a result of the release of pet shop turtles in the past. This western race (found from Missouri southward) of *Trachemy scripta* was frequently bred and sold in pet shops all over the United States, and has also been introduced to other parts of the world, including South Africa. The smaller Eastern Painted Turtles can be readily identified by the fact that their "scutes" (or external shell plates) present a straight line from left to right across their back, a feature not found in any other species of turtle. At Neely farm, hatchling Sliders can be found in shallow water in April, and the smaller hatchling Painted Turtles appear in June. Although I do like herons, I regret the fact that they appear around the margins of our ponds each year to feast upon these attractive little hatchlings! The older turtles can frequently be seen basking in the sun on the far margins of our fishing pond, even in the colder months of the year. In the summer, many will come forward to take bread crumbs dropped into the pond by visitors at our dock.

Our colorful Box Turtles also nest here, around woodland margins. The young conceal themselves, and are seldom seen. These are long-lived turtles, living perhaps more than 100 years, and the local population is most certainly dominated by older adults. Box Turtles feed on a diverse variety of earthworms, insects, berries, or plants, and are notoriously difficult to raise. Please be kind to these venerable denizens of our woods as they wander about. Because of their age, their need for special (including live) foods, and their reliance on seasonal weather changes, they should never be kept as pets. They are well-adapted to take care of themselves.

Tuesday, August 15, 2006 (September 2006)

Praying Mantids at Neeley Farm



Adult female of the green form of our larger native mantid, *Stagmomantis carolina*, photographed on the woodland floor near the fishing pond at Neely Farm. Because this area is now cleared of most organic matter each year, and has been denuded of topsoil as a result, you will probably have to look elsewhere for these remarkable creatures. They often live high up in our trees, seldom coming down to the ground level.

If you encounter a praying mantis, most likely it is one of two species. The largest is the Chinese Mantis (*Tenodera aridifolia chinensis*) often attaining a length of more than 4 inches. The Chinese Mantis was introduced to North America more than 75 years ago, for pest control, and is still widely distributed for this purpose. It is usually bright green. The smaller (2-3 inch) Carolina Mantis (*Stagmomantis carolina*) can be brown, gray, green, or any mixture of these three colors. The Carolina Mantis is native to our area, and it was officially designated the state insect of South Carolina in 1988!

Mantids usually sit on vegetation and wait for their prey (just about any insect) to come to them. Because of their colors and the fact that they are quite still, their prey do not see them until it is too late, when they make a sudden strike with their front legs. When waiting for prey, they hold these front legs up in the air, in a posture that makes it look like they are praying, hence the name. They are really "preying," but maybe they are also "praying" that prey will come their way! Mantids make great pets, and they are fun to watch. Not many insects will turn around and eye you the way that a mantis will. Often they will walk slowly, swaying back and forth like a twig blowing in the wind. Females do not really eat their mates on a routine basis, but they may do this if they are hungry. Females attach their egg sacs to plants in the fall, and then die. Young emerge in the spring as miniature adults, but lack the wings that only appear in the adult phase.

Friday, September 15, 2006 (October 2006)

Fungi in Our Lives

Mushrooms are just the visible bodies used by some fungi to get their microscopic spores into the air for distribution. Photo taken in the woods at Neely Farm.

Fungi (pronounced either "fun guy" or "fun ji," take your pick!) are all around us. After a rain, we often see mushrooms of many shapes and colors sprouting out of the earth. At Neely Farm, there are hundreds of varieties that you can discover, particularly in the woods. These include the bright red Amanita, or fly agaric, quite often very poisonous. Fortunately, most people are aware that collection and consumption of wild mushrooms requires considerable expertise, and many poisonous varieties look very much like the edible varieties. You many also notice fairy ring mushrooms or puffballs coming up in circles on your lawn, particularly after a heavy rain.

Mushrooms are just the visible bodies used by some fungi to get their microscopic spores into the air for distribution. Spores are produced and released from gills underneath the protective cap of the mushroom. The fungi that produce these mushrooms actually live their lives out underground, as microscopic fibers or hyphae (pronounced "hi-fi") branching out in the soil to collect minerals and to feed on decaying plant material. Shelf fungi, also abundant in many varieties, live inside of decaying wood and emerge to form hard, shelf-like structures that also release microscopic spores from their underside.

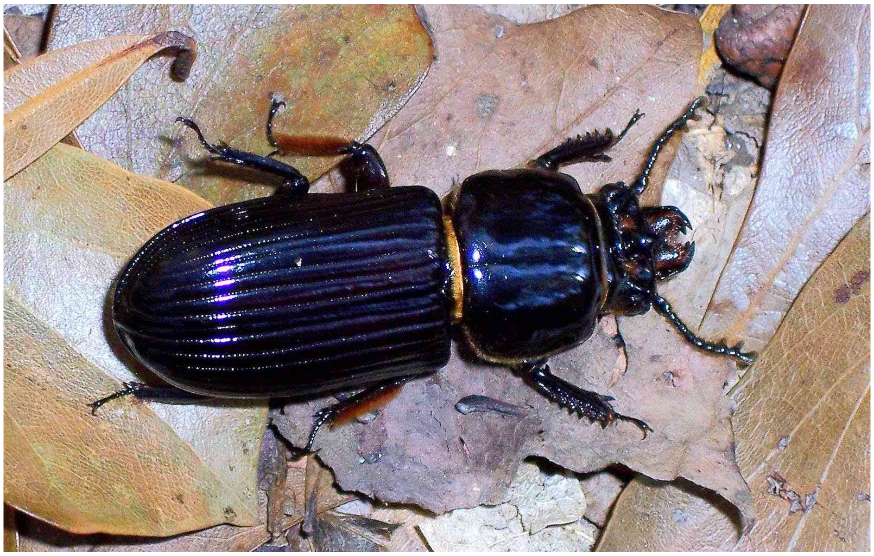
The other fungi that are readily observed are the many lichens growing on the bark of our trees, particularly on the north side where they are protected from sunlight. Lichens are actually formed by filamentous fungi that partner with microscopic green algae cells. The algae capture sunlight to produce sugars, and the fungi use these sugars for energy and in turn provide mineral nutrients to the algae. Lichens are used to monitor air quality. At Neely Farm we have many lichens because our air quality is very good. At some time, you may have lived in a highly polluted urban area where even fresh snow quickly turned black. In these areas, the sensitive lichens cannot survive.

Beyond these visible forms, fungi are all around us and very essential to life as we know it. Almost all higher plants, including our lawns, our trees, the plants in our gardens, and the agricultural crops that provide most of our food, depend on "mycorrhizal" fungi that live in association with their roots. These fungi break down fallen leaves and dying roots, and collect essential nutrients (both minerals and nitrogen) that are passed on to these plants. Fungi also produce many useful antibiotics, such as Penicillin, that they use to protect themselves from soil bacteria. Other fungi are used to raise our breads, to ferment sugars into alcohol, or to produce cheese from curdled milk.

People used to think that fungi were plants. Now we know that their DNA and biochemistry are actually much more like those of animals! Some people see fungi only as unwelcome mold in a wet spot, or as "problem" mushrooms that pop up in an otherwise immaculate lawn. In truth, we are completely dependent upon our partnership with this kingdom of microscopic filamentous creatures!

Friday, September 15, 2006 (October 2006)

Bess Bugs



Bess Bug (*Odontotaenius disjunctus*) in leaf litter, in the woods at Neely Farm.

If you encounter a large black beetle flying around a light at night, or even a pair of large black beetles living under a fallen log here at Neely Farm, there is a good chance that this is the wonderful creature called the "Bess Bug!" These are also known to rural folk as Betsy Beetles, Patent-leather Beetles, or Peg Beetles. Scientists call them "horned passalids" or *Odontotaenius disjunctus*. These are really *beetles*, not *bugs*, and they are close relatives of the scarab and stag beetles, also found here. Like most beetles, their first pair of wings are hard and protective, and meet in a straight line down the back. In bugs, the first pair of wings overlap. This is the only member of the family Passalidae found in the Eastern United States, and it ranges from Colorado in the West to Florida in the Southeast.

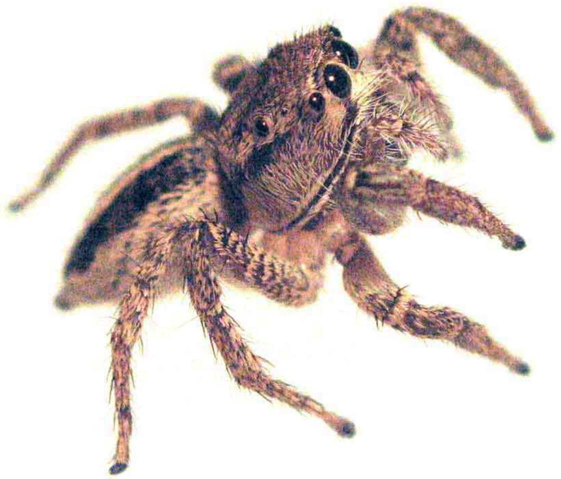
Bess bugs can be readily identified by their large size (about 1 $^{3}/_{8}$ inch in length, or larger), their deep black ("patent leather") color, their compact but strong "pinchers," the small horn at the front of their head, and the many "striations" or lines on their hard wing covers. They also have many fine red-brown hairs arranged as a comb on their second pair of legs.

Bess bugs are often found as pairs, because they mate for life. Male-female pairs chew up rotting wood and prepare a mixture that they carefully feed to their young larvae. This mixture includes microscopic bacteria and protozoa that live within each beetle and do the actual digestion of the rotted wood, something these beetles cannot do by themselves. By the way, our common wood roaches (*Cryptocercus punctulatus*) do the same thing. Such close parental care is remarkable enough for a beetle, but their communication with sound is even more remarkable!

Bess bugs do not bite, despite the formidable appearance of their jaws. If you pick one up and hold it close to your ear, you can hear it "squeaking." This sound is made by rubbing the wings (under the wing covers) against the abdomen. The grub-like larvae also "speak" quietly by rubbing their hind legs against their abdomen. More than 14 distinct sounds have been identified to date, each used for a specific purpose. These include warnings, courtship signals, and sounds of aggression between rival beetles. We still have much to learn about this form of communication.

Sunday, October 15, 2006 (November 2006)

Jumping Spiders


Adult female *Habronattus orbus*, a small (6-7 mm) ground-dwelling jumping spider that frequents open spaces in our area. Unlike most jumping spiders that jump with their hind legs, *Habronattus* can jump high off the ground with a powerful third pair of legs. Sit quietly on open ground near a woodland to see these jumpers in action!

You may not see them, but they see you! Many people have never seen a jumping spider, or they don't recognize them when they do see them.

Jumping spiders have a pair of very large eyes in front. These large eyes give jumping spiders better vision than any other spiders. In fact, they have far better vision than any insect, and their ability to see detail is not that much less than our own! They also have 6 other eyes, a total of 8 eyes, that allow them to see in all directions at once! With these eyes, they see their prey, and everything else around them. If you are even 10-20 feet away, or more, they can see you. Like squirrels, they immediately move out if sight, around a branch, or under a leaf. From these concealed positions they squat down and watch you, to *see what you are* and *what you are doing*. Most likely, you are *large and dangerous*, and you will not see the jumping spider that has seen you first.

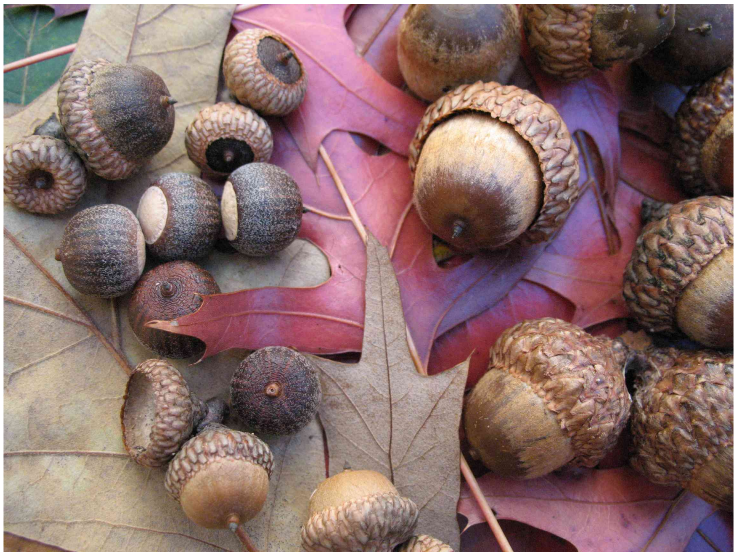
Jumping spiders, like small cats, stalk their prey and then jump upon it from a distance. They also jump as they move, from place to place. As they move, they let out fine lines of silk, each stronger than steel, in the form of a drag line. This is like a bungi cord, and after a jumping spider jumps into the air to capture a fly, it can swing in place on this cord, and then climb up the drag line while holding its prey.

At the end of each foot, jumping spiders have a pair of retractable (like cats!) claws for climbing on silk, and also a pair of adhesive foot pads that can also be moved back and forth. These foot pads are covered with minute hairs, and these minute hairs in turn are covered with rows of even smaller hairs, each bearing a flat triangle at the tip. When these triangles are brought very close to a surface, they stick by means of *van der Waals* forces (You may remember these from high school chemistry!). This mechanism is known as *dry adhesion*, as no glue is required.

There are many kinds of jumping spiders around us, as many as there are kinds of birds. Most of them do not have common names, so we have to use their latin or scientific names! To see them, you need to be *very quiet*, sit *very still*, and you must be *very observant* for signs of movement around you. Eventually they will come out of their hiding places and you can watch them moving around. Some of the more common kinds in Neely Farm are: the flattened *Platycryptus undatus*, a grey-brown form about 1 cm in length that stalks gnats and mosquitoes on our houses, the relatively large *Phidippus princeps*, a brownish spider a little more than 1 cm in length that lives on herbs and shrubs around woodland borders, and the brilliant green, long-legged *Lyssomanes viridis*, a small (6 mm) spider that frequents the underside of our evergreen *Magnolia grandiflora* and *Rhododendron leaves*.

Sunday, November 12, 2006
(December 2006/January 2007)

The Mighty Acorn



This is the season of abundance and Thanksgiving, of fallen leaves and tumbling acorns. At left are the small but attractive acorns of the Southern Red Oak. At right are the much larger acorns of the Scarlet Oak.

We are fortunate at Neely Farm to have many native oaks growing in our yards and woodlands. The genetic diversity of these trees in the Southern Appalachian region can make identification difficult at times. The most commonly encountered native oaks in our neighborhood are: White Oak (*Quercus alba*), Southern Red Oak (*Q. falcata*), and the Water Oak (*Q. nigra*). Some of the other, less abundant species include the Scarlet Oak (*Q. coccinea*) and the Willow Oak (*Q. phellos*).

White Oaks in this area are generally less than 100 years old, but they can live for 600 years or more, with a diameter exceeding four feet. The White Oak is considered to be the most common tree in the Eastern United States, but it is also the most valuable oak because of the quality of its timber. These trees can be identified by their lobed leaves with rounded tips, and also by the tendency of the bark of younger trees to peel off and fall to the ground. The bark is distinctively lighter ("white") when compared to that of other oaks. They live on well-drained slopes.

The Southern Red Oak also lives on well-drained slopes. These oaks are distinguished by their variable leaf shape, but leaves generally bear an elongated, pointed central lobe. The leaves are dark green and waxy on top. Leaves are slow to change color in the fall, and green leaves are often seen well into December. This tree is sometimes called the Spanish Oak. The native range extends from the Ohio River Valley southeast as far as northern Florida. These trees have a hard, strong, coarse-grained wood that is also valued in construction.

Water Oaks grow rapidly, usually in lowlands or along streams. They are more common in areas closer to Rocky Creek, at the bottom of Neely Farm. Their leaves are smaller, and are either shaped like a spatula or a "duck's foot." In the right location, a Water oak can retain its green leaves for much of the winter ("nearly evergreen"). We live near the northern limit for this tree, which can be found as far south as central Florida.

Scarlet Oaks have large acorns and bright red leaves in November. Unlike other oaks, the limbs of the Scarlet Oak tend to spread out and curve downward as they grow. These are excellent shade trees if grown in open areas, but they do not grow well in the shade. They grow more rapidly than do other oaks, and thrive on well-drained slopes with poor soils. Their native range extends from southern Pennsylvania to the fall-line near Columbia, and they do not occur naturally in the low country.

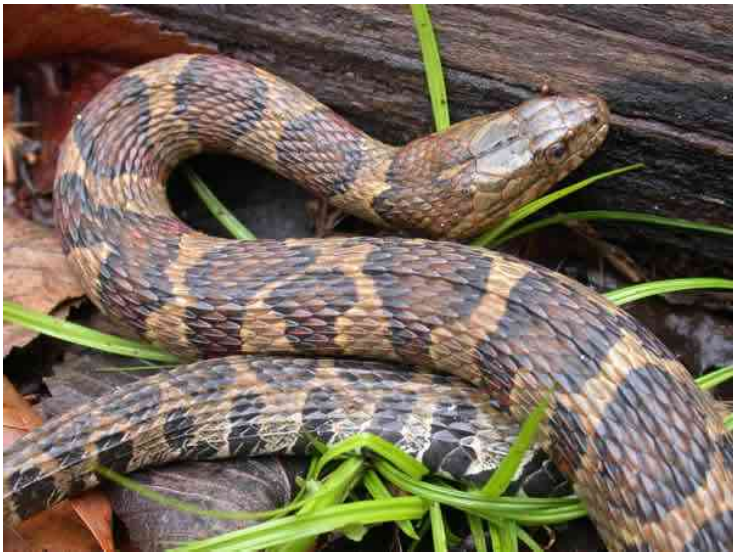
Like the Water Oak, Willow Oaks are usually found near streams, but these attractive, "nearly evergreen" trees have been planted in many locations (for example, along Harrison Bridge Road, or in parking lots on Fairview Road!). As the name indicates, the leaves of these oaks are elongate and resemble those of the willow. These are distinctive trees that thrive at lower elevations, in the humidity of the coastal plain from Virginia to South Carolina. The southern end of Greenville County is at the very edge of their natural range.

At this time of the year, our oak trees shed a crop of acorns, most of which have been developing from flowers that appeared more than two years ago. Acorns that manage to survive the attack of acorn weevils and other insects in the trees provide a natural bounty for our squirrels. A wide range of other birds and mammals also depend on this crop. This includes the Blue Jay, Carolina Wren, Crow, White-breasted Nuthatch, Mallard, Wild Turkey, Eastern Chipmunk, Red Fox, Virginia Opossum, and the White-tailed Deer.

Fortunate is the acorn that gets buried in the right place by a squirrel that fails to find this "larder" at a later date. If successful, this acorn will rise to become one of the majestic giants of the forest, in turn sharing its bounty with all of the forest creatures below. *There is no better way to share this miracle of life than to let your children gather and sprout an acorn, and, if possible, watch what happens to this little sprout as the years pass.*

Thursday, January 11, 2007 (February 2007)

Fishers at the Pond



Water Snake (*Nerodia sipedon*) from a farm pond in Mecklenburg County, North Carolina (photo by J. D. Willson, used by permission)

Water Snakes (*Nerodia*) and Black or Yellow Rat Snakes (*Elaphe obsoleta*) are the most commonly encountered snakes in Neely Farm. Unfortunately, a lot of people mistake these non-venomous and beneficial snakes for the poisonous pit vipers (either rattlesnakes, copperheads, or water moccasins). Young rat snakes often bear regular patterns that resemble those of a small rattlesnake.

Our common Water Snakes (*Nerodia sipedon*) are even worse in this respect. These attractive, banded snakes (2-4 feet in length) range from black to brown to red in color, and they can resemble various rattlesnake species (including the Eastern Diamondback!), Copperheads, or Water Moccasins. In addition, if threatened they can flatten out their heads and hiss, or even wave their tails like a rattler. Water Snakes should be admired from a distance for their graceful swimming movements, but should never be picked up, as they will readily release musk and bite when threatened. Their bite includes an anti-coagulant, so those who are bitten bleed freely, but fortunately there is no venom involved and no real danger. Just don't pick them up!

Although the venomous Water Moccasins can be abundant in the low country of South Carolina, their natural range does not include our area. Water Snakes are common in the Upstate, and throughout most of the Eastern United States. So if you see a snake swimming in the water of Rocky Creek, in our pond, or along one of our tributary streams, it is almost certainly a harmless Water Snake.

Water Snakes feed on just about any kind of animal that they can see, feel, or catch, including fish, amphibians, other reptiles, leeches, insects, and even mice. Their primary enemies in this area include raccoons, opossum, foxes, herons, owls, hawks, crows, and rat snakes. Water Snakes are viewed as beneficial to game fish populations as they feed on diseased, weak, or dying fish and help to thin out schools of young fish. They feed both day and night, but usually capture small fish in the shallows at night. They often herd small schools of fish or tadpoles into a group near the shore to make them easier to capture.

These snakes emerge to bask in the spring, and they mate in the April to June time frame. After a 3-5 month gestation period, they bear 4-99 live young (more for larger females) later in the summer (August to October). Water Snakes are ovoviviparous, as the young hatch from eggs carried by the female.

Snakes are important and attractive members of our local ecosystem, and they deserve at least our respect if not our interest. Two years ago, Water Snakes could be seen frequently along the shores of the pond at Neely Farm in the spring, but last year I could find few, and the largest one I found had just been killed by some misguided individual (who also smashed every mushroom in the area!). If you encounter a snake and do not understand it, please ask for assistance in identification and/or removal if you have a problem!

February 12, 2007 (March 2007)

Sprouts and Butterflies

Photograph of flowering Butterfly Weed (*Asclepias tuberosa*) taken in August of 2005. Inset photographs: (upper right) a newly emerged sprout of this plant, and (lower left) the familiar Monarch or Milkweed Butterfly, *Danaus plexippus*.

With the coming of warmer temperatures and spring rain, tiny seeds begin to germinate in our soils. Most of our herbaceous plants are called *dicots* (short for dicotyledons) because they emerge from their seeds with a pair of embryonic leaves (the cotyledons). As these embryonic leaves turn green and expand to collect sunlight, a single rootlet drives ever deeper into the earth to obtain vital nutrients and water. Only the most fortunate of these tiny and delicate sprouts grow and live long enough to flower and produce seed. Most are crowded out by surrounding plants, or trampled, or eaten.

When we think of wildflowers, we most often think of perennial herbaceous plants. Most herbaceous plants are soft-stemmed, and they grow in abundance in prairies, along woodland margins, or in the shade of undisturbed woodlands. Many, if not most, of our native butterfly species are dependent upon these plants. For example, the Monarch Butterfly will only lay its eggs on milkweeds (*Asclepias*).

As much as we value wildlife, we tend to destroy our native wildflowers. Small plants in the woodland understory are trampled by the traffic of humans and their domesticated animals or vehicles, and most species are slow to recover. As a result, such plants as the Cardinal Flower, Dutchman's Breeches, Bellworts, Wild Ginger, Hepatica, and Trillium are rare and most people have never seen them in this area. When colonists first came to this continent from Europe, all of these plants were abundant and they carpeted our woodland floors, thriving in the sunlight that penetrates the forest in early spring.

Native prairie or savanna habitats that can support sun-loving perennials like the Butterfly Weed are even more endangered than woodlands. With suburbanization of rural areas, low-cost old field habitats rich in herbaceous plants are replaced with lawns filled with a handful of high-cost, cultivated, and introduced grass species. The introduced grasses crowd out other small plants, and herbs that manage to germinate are chopped down and killed by a host of lawn mowers, trimmers, or herbicides. Other prairie areas are cultivated for agriculture. In upstate South Carolina, even untended old fields eventually fill with pines and then hardwoods, to become woodlands.

The extensive and open prairie or savanna areas of Eastern North America prior to settlement by Europeans were most likely the result of both natural fires and the managed agricultural activities of native Americans. We know that even pine forests can only survive through periodic fire, and it is likely that part of the function of pine needles is to provide the kind of kindling that supports maintenance of an open habitat. Tall pine trees attract the lightning spark, and their fallen needles provide the kindling. Open areas emerge, and new sprouts grow into a diverse savanna community of herbaceous plants. These, in turn, are discovered and exploited by the wandering butterflies and a host of other creatures.

In North and South Carolina, state agencies have been naturalizing areas along major highways in order to improve their beauty, and to reduce the cost of highway maintenance. You may have seen some of the colorful wildflowers along Highway 25 on the way to Asheville, or along Interstate 385 between here and Columbia. In many cases, controlled burning is not an option. After a prairie has naturalized for about three years, an annual (winter) cutting may be required to prevent the growth of forest plants. Timing of this cutting is critical, to avoid damage to these plant communities.

Sun-loving sprouts and their attendant butterflies are delicate, and both live by dispersal and colonization of open areas. We can enjoy these creatures in our neighborhood and the surrounding countryside only to the extent that we can reserve and maintain a protected place for them to live.

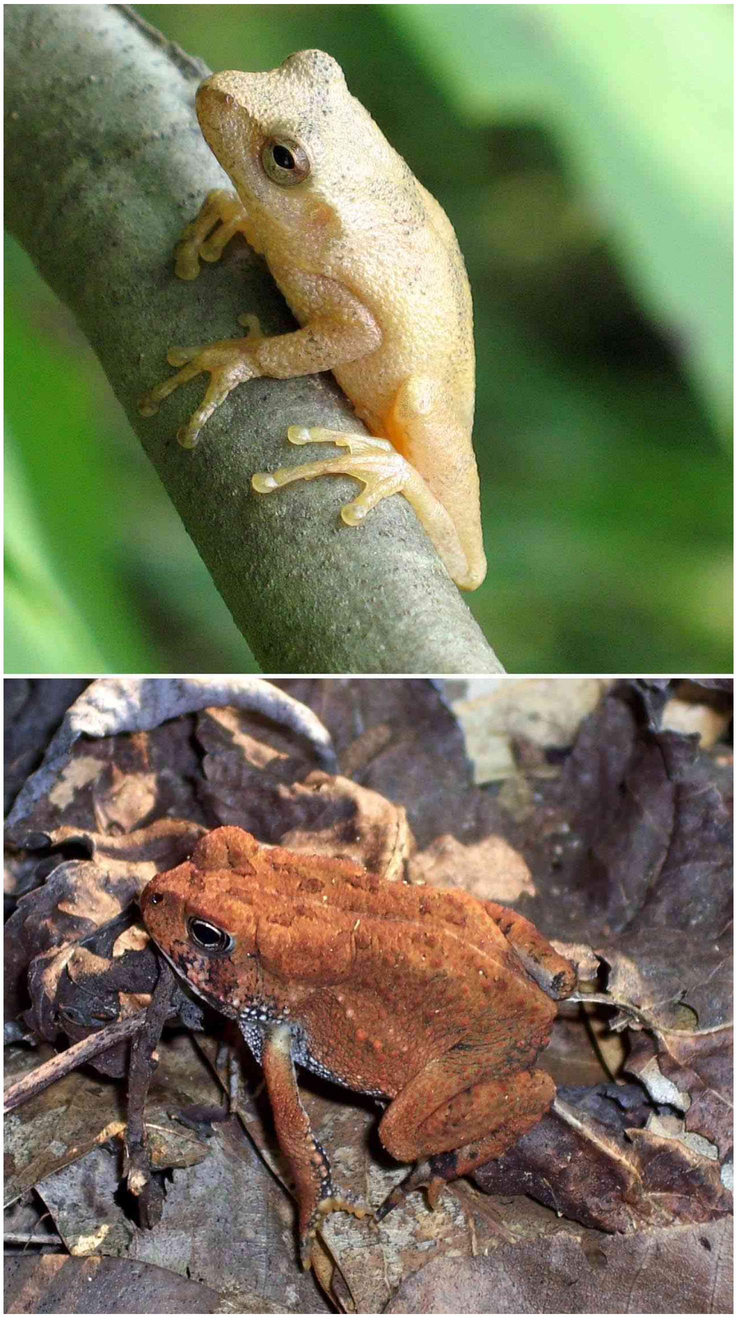
Tuesday, March 13, 2007 (April 2007)

A Chorus of Frogs and Toads

Frogs and toads can be heard throughout the year in Neely Farm, but they are at their best after warm rain and warm nights return in the Spring. The many songs that you hear represent the males, calling out the females. Most tend to be nocturnal, and conceal themselves to avoid visual predators (notably birds) during the day. Many of the more than 30 species of frogs and toads (anurans, or tailless amphibians) that are known from South Carolina can be found here. The most common are the tree-dwelling tree frogs (*Hyla* or *Pseudacris*) and the ground-dwelling toads (*Bufo*). Pond frogs (*Rana*) can also be found in or near more permanent bodies of water.

Pond frogs, or typical frogs, have long legs and webbed-feet that make them strong swimmers and jumpers. Their longest jumps usually propel them from the shore to the relative safety of a pond. Toads have tough, stubby toes, well-suited for burrowing. They only make short jumps as they move about, or jump at prey. They also have thicker skins that allow them to survive dry periods, as well as neck-pads that secrete protective toxins. Tree frogs, including our chorus frogs or peepers, have adhesive toe-pads that allow them to cling to twigs and branches. These work like small suction-cups with wet adhesion, and they are peeled off of the surface as the tree frog moves. Tree frogs often walk along branches, but they can also jump long distances. Many tree frogs can also change color to conceal themselves, usually from shades of gray or brown to green. Pond frogs and tree frogs respire through their moist skin, to supplement the relatively small volume of their lungs.

All of these frogs and toads feed on insects, spiders, slugs, earthworms, and other invertebrates that they encounter. They can eat surprisingly large numbers of these animals. They are very sensitive to movement, and quickly detect prey with their large eyes and acute vision.



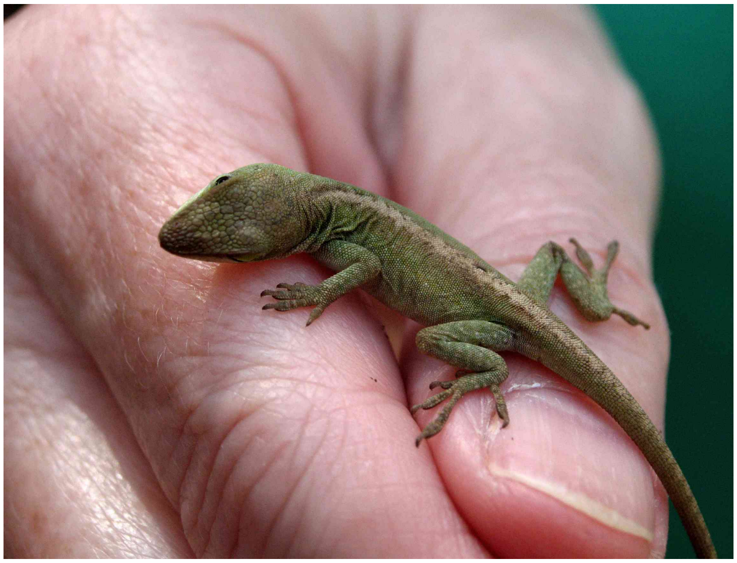
Tree frog with foot pads (top), and toad with claws (bottom), from the woods at Neely Farm.

Frogs and toads are dependent on temporary ditches, ponds, creeks, or blocked creek drainages, where they lay their eggs. Amphibians do best in slower waters that have few predatory fish. Usually water must be available for at least 30 days for the tadpoles to hatch, grow, and emerge as young frogs or toads capable of surviving out of water. Toads emerge early as tiny (1 cm or 1/2 inch or less) "toadlets" to complete most of their growth on land. Toads do not drink water, but can absorb it directly though their skin. All thrive in conditions of high relative humidity.

Unlike the adults that take live prey, tadpoles feed primarily on decaying or plant matter. Children who are given the opportunity will delight in following the miraculous growth of tadpoles as they transition from their limbless, tailed, finned, and gill-breathing tadpole form to their legged, tailless, lung-breathing adult form. Once they emerge, the adults can be released to hunt on their own. For anyone with a serious interest in these animals, I strongly recommend the book *Frogs, Toads, and Treefrogs*, by R. D. and Patricia P. Bartlett. These creatures, in all of their diversity, truly define the word "amphibious." With the accompaniment of a myriad of tree-crickets and katydids, they emerge each year to sing the boldest songs of our warm summer nights.

Saturday, April 14, 2007 (May 2007)

The Carolina Anole



Juvenile *Anolis carolinensis* resting on the hand of Rose Marie Hill at Neely Farm.

We are fortunate to have many of the delightful Green or Carolina Anoles (*Anolis carolinensis*) as neighbors here at Neely Farm. These small (to 8 inches, or 20 cm in length) lizards are frequently sold in pet shops as "chamaeleons." Like true chamaeleons (only found from Southern Europe through Africa to Madagascar), these lizards can change color (from green to brown), but they are more closely related to new-world iguanas. Like chamaeleons, they can also move their turreted eyes in different directions, to look both forward and backward at the same time. To support their arboreal life style, Anole lizards have a series of adhesive plates (or lamellae) under each toe. As in gecko lizards, each adhesive lamella is finely divided into thousands of microscopic projections that attach to a surface (If you can remember your high-school chemistry, *van der Waals* forces are thought to be involved). Almost 400 species of *Anolis* have been described to date, many from tropical islands of the Caribbean, but the Carolina Anole is our only native species, with a range in the Southeastern United States that includes the entire state of South Carolina.

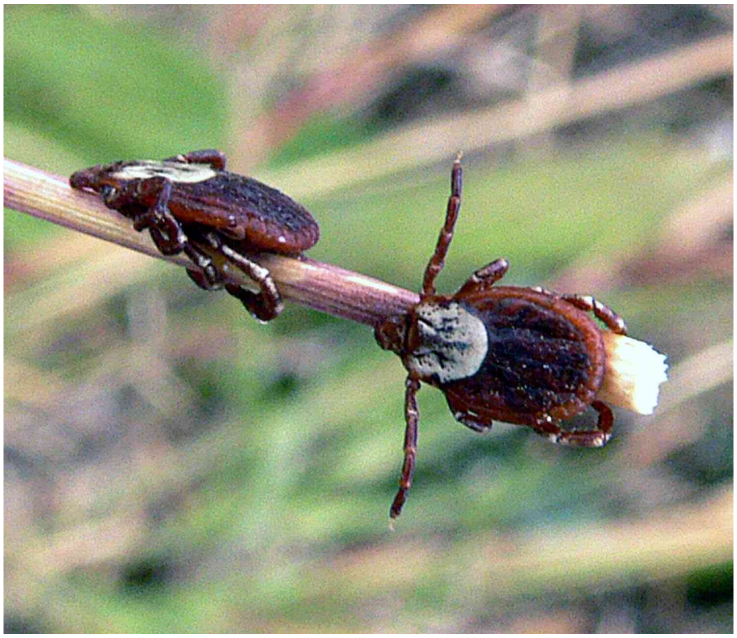
Anole lizards are quite common in our area, but you may not see them in your yard very often. They feed on all kinds of invertebrates (mostly insects and spiders), but in turn they are preyed upon by many birds and mammals. If a predator grasps one of these lizards by the tail, the tail is detached and continues to twitch as the lizard scurries to safety. Over time, a lost tail will be regrown (regenerated). Anoles most often live high up in trees, concealed by the leaves or in bark crevices, and may seldom venture down to a level where they are visible. During one summer drought, we saw several of these lizards carefully climbing down to drink water droplets off of our Gardenias, then hurriedly running back up the tree trunks to the relative safety of the canopy. Your best chance to see these lizards is when they are basking in the sun in the early morning, particularly if they like to frequent areas around your house, including stair-rails. Adult males (up to 9 inches or 22 cm in length, somewhat longer than females) have a conspicuous red to pink throat-sac (or dewlap) that they extend during their territorial displays. During warm weather, females deposit single, round (only 8 mm or 1/4 inch diameter!) eggs in rotting wood, or buried in the soil. They can lay a new egg every two weeks. The young are smaller than a child's thumb, and quite remarkable to observe if you can find them.

Other lizards found at Neely Farm include the Eastern Fence Lizard (*Sceloporus undulatus*), the Six-lined Racerunner (*Cnemidophorus sexlineatus*, a *very fast* ground lizard), and Lined or Blue-tailed Skinks (Eumeces, several species, ground-dwelling with distinctive blue tails). All of these lizards appreciate the refuge provided by a brush pile or dead wood lying on the ground, and they make take refuge under your screen porch as well. As their name suggests, Fence Lizards often frequent fences, or the trunks and branches of medium-sized trees, not too far off of the ground. None are as arboreal as the Carolina Anole.

The wonderful Anole lizards really do make good pets, and they are easy to rear. Unfortunately, as pets most of them are handed over to the care of children with no knowledge of their need for space (at least a 20 gallon *terrarium*, screened for ventilation and fitted with plants), light (some UV), heat, water (mist or droplets), and live food. With the right kind of parental supervision, however, pet Anoles can thrive for more than seven years in captivity.

Monday, May 14, 2007 (June 2007)

Mites in our Midst


Female Pacific Coast Ticks (*Dermacentor occidentalis*) at the end of a grass stem, waiting to grab onto the next passing deer, horse, or human. For obvious reasons, ticks can be abundant in areas frequented by deer. This species is not associated with Lyme Disease, as is the Deer Tick. Photo courtesy of Linda Tanner, used subject to a Creative Commons Attribution 2.0 Generic license.

The largest mites (veritable giants in the group!) that you are likely to encounter are the "wood ticks." Several species can be found (or they find us) in Upstate South Carolina. The largest and perhaps the most common, the American Dog Tick (or simply, Wood Tick), can give you either Colorado Tick Fever or Rocky Mountain Spotted Fever. Smaller ticks like the Lone Star Tick (identified by a conspicuous white spot, can give you either Rocky Mountain Spotted Fever or Erlichiosis), and the perhaps less common Black-legged or Deer Tick (can give you Erlichiosis, Babesiosis, and the dreaded Lyme Disease) are more to be feared by humans.

The other mites that you may have seen are the much smaller red velvet mites that crawl around on the ground. Velvet mites (many species) are fierce predators, feeding on insect eggs or attacking insects many times their own size. There are many similar, red, green, or brown, water mites in aquatic habitats. Some parasitize dragonfly larvae in the water, and then molt and emerge with the adults to disperse to new areas. Others are predators. If you spend any time in the "Southern Bush," then you have most certainly felt (but not seen!) the related harvestmites or chiggers. These usually attack us in areas of tight-fitting clothing. I have found that, after exposure, a good shower with lots of soap can prevent a lot of later suffering from these creatures!

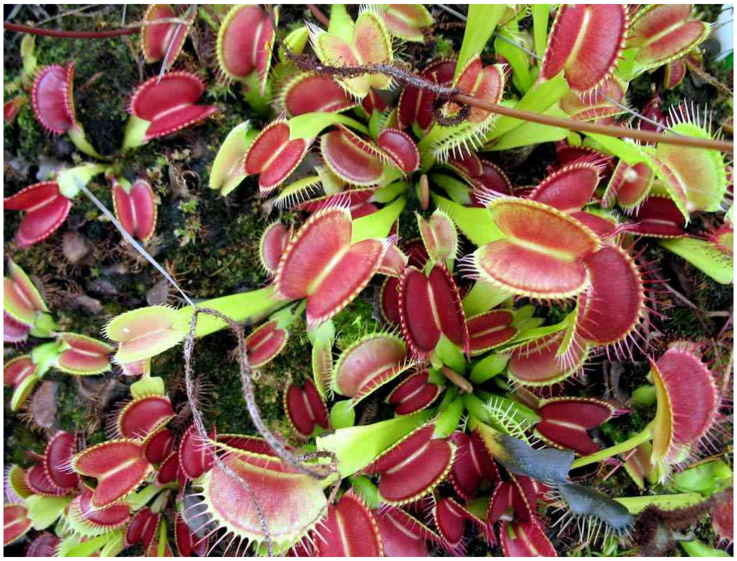
So what are mites? The eight-legged mites are acarines, a group of arachnids related to scorpions, harvestmen, and spiders. Mites have been studied in universities primarily because many (for example, spider mites) are serious crop pests. Although tens of thousands of mites have been named and described, it is possible that there are more species of mites (perhaps 1,000,000 or more!) than of all other kinds of plants and animals, combined! Most are very small, and you will never see them. By small I mean MICROSCOPIC (1/10 of a millimeter or less)! Mites are everywhere! Indoors, we have dust mites feeding on debris in our households, but we also have follicular Demodex mites that live in and between our hair follicles. We have mites (for example, cheese mites) that attack our food stores. Outside, mites are crawling all over the place, feeding on small plants, animals, bacteria, and fungi (mold), or parasitizing just about anything that moves (including birds, reptiles, and insects). In fact, the recent worldwide decline in Honey Bee populations has been attributed to mite infestations. Most if not all plants are infested by these creatures.

So what's the upside? Well, from the point of view of the mite, life is very good indeed. Biologists consider mites to be one of the most successful and diverse life forms on earth. It is amazing that such complex, multicellular creatures can be so small, even smaller than some single-celled protozoans! And then there is the fact that, like it or not, even herbivorous animals eat untold numbers of these creatures with their food, thereby gaining a certain measure of improved nutrition. Some mites are routinely introduced to control harmful spider mites, or harmful insects including thrips and the fire ant. In fact, one of the key success factors associated with small-scale agriculture (no chemicals) is the ability of predatory mite populations in nearby natural borders to keep pest species at bay. So if mites are not devouring all of your garden plants (and your trees!), you assuredly have have a host of other, predatory mites to thank for your bounty!

Saturday, June 16, 2007 (July/August 2007)

Plants from Venus!

Many if not most people would think that the Venus Fly Trap (*Dionaea muscipula*) is the strangest plant on planet earth. If you ask people in the Carolinas where they come from, you may hear a litany of exotic places: Borneo, Papua New Guinea, Zaire, Brazil, and *anywhere else*. Actually, the Venus Fly Trap occurs naturally *only in North and South Carolina*, surviving in boggy areas in several coastal counties here!



Colorful red form of the Venus Fly Trap, *Dionaea muscipula*. Photograph courtesy of Orin Zebest, use subject to Creative Commons Attribution 2.0 Generic license.

The Venus Fly Trap, like other carnivorous plants (including bladderworts, sundews, and pitcher plants) does not prey upon animals to get calories. These plants usually live in wet areas with little available nitrogen, and they must obtain this essential nitrogen from the nucleic and amino acids (or protein) in the animals that they capture and digest. This may seem strange, considering the fact that nitrogen is abundant and constitutes 78.1 percent of the air that we breathe. How can nitrogen be scarce?

It turns out that plants can't get ("fix") this abundant atmospheric nitrogen. Only specialized bacteria have the biochemical nanomachinery to bind atmospheric nitrogen with hydrogen atoms, to produce ammonium ions that can be used by other organisms. The bacteria that do this live deep in the soil and tend to avoid oxygen as well. Most live in the root nodules of plants such as legumes, where in turn for protection they supply ammonium ions. The plants then convert these into more useful nitrogen oxides and amino acids.

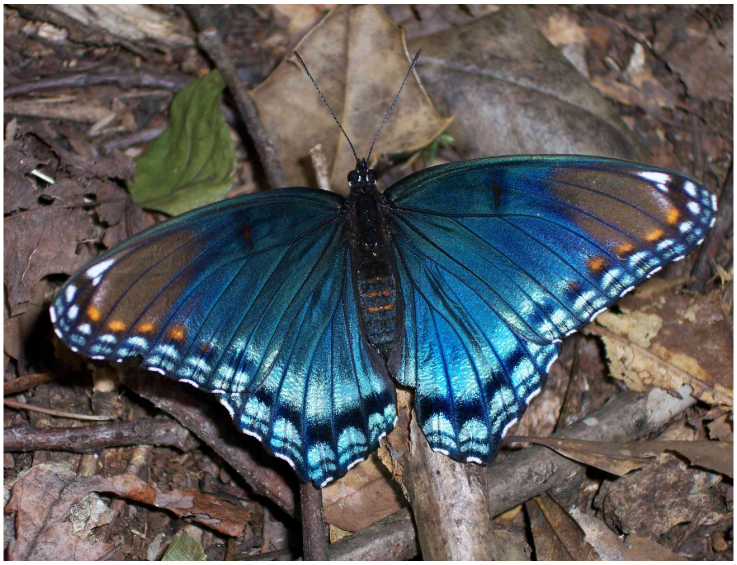
So how does the Venus Flytrap work its magic? Each trap is "sprung" in about 1/10 of a second by the mechanical stimulation of small trigger hairs on its inside surface. For some time, scientists have wondered how this happens, and even now the trigger mechanism is not understood well. It appears that a biochemical process in certain cells is triggered by this mechanical stimulation, a process that causes those cells to rapidly deflate (loss of water pressure or turgor). This deflation then triggers the buckling or rapid folding of the entire leaf, to close the trap. The actual energy driving the rapid buckling of the leaf as it captures an insect was stored in the structure of that leaf as it grew, much like a pre-loaded spring.

If you want to grow some Venus Flytraps, they are easy to obtain, and not very hard to grow as long as you can supply them with poor, wet, acid soil and lots of sunlight. They also do well in a terrarium. In the wild, these plants are generally protected because of their scarcity, and should not be disturbed. The opportunity to observe these remarkable flowering plants in their natural habitat is one of the great advantages of living in South Carolina. One place that I would recommend is Carolina Beach State Park, just south of Wilmington, North Carolina. This park has a hiking trail dedicated to the Venus Flytrap. With the North Carolina Aquarium (Ft. Fisher) and Kure Beach in the vicinity, you can make a full day of it.

Sunday, August 12, 2007 (September 2007)

Gathering of Red-spotted Purples

One of the most frequently encountered butterflies at Neely Farm is the Red-spotted Purple (*Limenitis arthemis*), also known as the Red-spotted Admiral. This is considered to be the same species as the White Admiral found in the Northeast, but does not have white bands on its wings. They are also closely related to the orange Viceroy butterfly, and have been known to hybridize with these. These relatively large butterflies are attractively spotted on the underside of their wings, but are most readily recognized by their brilliant blue to blue-green iridescence, and their gracefully gliding flight. Like other brush-footed butterflies (Nymphalidae) purples are quadrupeds, only walking on four (not six) legs.


Red-spotted Purple (*Limenitis arthemis*) resting on the ground in the woods near the fishing pond at Neely Farm.

Many butterflies collect nectar at flowers to obtain energy ("empty calories"), just as hummingbirds do. Whereas hummingbirds (like our local Ruby-throated Hummingbird, *Archilochus colubris*) capture insects to obtain proteins for their young, butterflies must obtain most if not all of the protein for their eggs when they are still growing caterpillars, and their adult food consists of little more than sugar water. Some butterflies (particularly males) also collect salts deposited along shorelines.

Purples seldom frequent flowers, but do drink large quantities of tree-sap, especially during hot or dry weather. If rotting fruit is available, they will feed on it. Good tree-sap sites are not common, and are generally the result of an injury to a tree (such as our local White Oak, *Quercus alba*). Tree injuries may be caused by beetles that bore into a tree trunk, but once they occur they are maintained by a number of insects, including wasps that help to maintain these vital sap resources with their jaws. Once available, a good sap site is used year after year by many different ants, wasps, and flies. Butterflies that frequent sap sites in our area include the Red-spotted Purple, Hackberry Emperor, Red Admiral, and the Question Mark (all nymphalids, or brush-footed). If you find one of these sites, you may observe a gathering of a dozen or more of these brush-footed butterflies, all jockeying for position in the sap flow.

When feeding at these sites, Red-spotted Purples aggressively flex and extend (open) their wings, driving away other butterflies and insects so that they can get to the sap. You may also observe purples opening their wings as they bask in the sun, or walk about on the ground. Because of their coloration, they are thought by some gain protection by mimicking the poisonous Pipevine Swallowtail, also found in this area. Pipevine Swallowtails, however, frequent flowers and not sap sites, and behave quite differently (for example, they tend to hover when feeding at flowers).

In our warm climate, Red-spotted Purple butterflies can be seen most months of the year. They have at least three successive generations each year, and, unlike some other large butterflies (including Monarchs, Buckeyes, and Gulf Fritillaries), they are not obligate migrants to warmer climes in the Winter. With each successive generation, the population of these butterflies increases, so that by late summer they can be quite abundant. In October, caterpillars construct hibernacula with rolled-up leaves and silk, and may overwinter in these until they pupate and emerge as adults in the Spring.

Food for the caterpillars is quite abundant in our area. Like our Eastern Tiger Swallowtail, they really seem to like cherries (*Prunus*), but also feed on many other plants, including apples, hawthorns poplars and even some oaks and willows. If you really want to encourage them, plant Wild Cherry (*Prunus serotina*), which grows very well here.

Butterflies are great subjects for study, more for observing and photography than for collecting these days. I highly recommend the recent book by Rick Cech and Guy Tudor entitled Butterflies of the East Coast (2005, Princeton University Press). This is an outstanding introduction and reference for people of all ages and backgrounds. If you really get interested, visit the butterfly garden at our local Roper Mountain Science Center (Thank you, Ginger Kopka!), or look into activities of the Carolina Butterfly Society (www.carolinabutterflysociety.org). The University of Florida (Florida Museum of Natural History) in not-so-far Gainesville also has one of the premiere (and newer!) butterfly research institutes in the world, with wonderful public exhibits including live tropical species in flight (www.flmnh.ufl.edu/butterflies). Otherwise, just enjoy these graceful beauties in our neighborhood!

Saturday, September 15, 2007 (October 2007)

The 'Bard' Owl

Technically, it's called a 'Barred Owl' (*Strix varia*) because of the plumage. Since most people will only hear the distinctive baritone voice of this large (wingspan can exceed four feet), year-round resident of the swamp-forest, but will not see it, it may be more appropriate to call this vocal bird a 'Bard' Owl. They're also called *hoot* owls (the most vocal of owls!), eight hooters, striped owls, rain owls, wood owls, or swamp owls. In South Carolina, there are probably at least twice as many common names for the Barred Owl as there are counties! Their distinctive call (*Who cooks for you... Who cooks for you 'all*, or boo boo ho-ho...hoo boo ho-hooooooaw) has a distinctive drawl at the end of it, as it should in these parts. If you listen, you can hear a lot of other sounds (*gurgles, cackles, screeches, hoots, cries, slurs, calls, yells, even blood-curling screams*) if there is a good conversation going on between these talkative creatures. You can hear these 'Bards' calling at all times of the day and night, but perhaps most often in the late afternoon and evening, then past the twilight hours into the night. I've seen them quite alert and awake in the middle of the day, and they are also said to hunt at all times. Spring and Fall are the best times of the year to hear them defend their territories.

Sentinel by D. F. Landau. Acrylic on hardboard, collection of D. E. Hill.

Neely Farm indeed has its own haunted swamp-forest, if only small, and only flooded in season. Our swamp-forest does need some tending, to preserve its character. Nothing to compare with the great Congaree below Columbia, but also haunted by these wonderful 'Bard' Owls. It is thought that Barred Owls hide out in these relatively dark places because they do not fare well in the presence of their competitor and predator, the larger Great Horned Owl, an inhabitant of more open woodlands. As swamp-forest habitats decline, Barred Owl populations also decline. In the Neely Farm woods, squirrels, flying squirrels, opossums, rabbits, and shrews provide a wide variety of mammalian prey. With their powerful talons, they can capture prey as large as the wood chuck! They also eat just about anything else that they can catch, including other birds (among these herons or geese), frogs, snakes, lizards, and even insects. If available, they will also take aquatic prey, including crayfish and fish, by wading.

Barred Owl pairs tend to remain in the same area for years, entertaining us with haunting duets. Only the larger females brood the eggs, often in a large tree hollow, but the males hunt and bring back food for the whole owl family.

A favorite activity of many young naturalists is the collection and dissection of owl pellets. Finding these pellets Usually near an owl roost) takes some skill, but their careful dissection reveals the undigested bone fragments of their prey.

A silent observer, by moving slowly and quietly, can sometimes approach and observe these animals. On this note, I can recall a wonderful morning hike in the backwoods of Northern Florida, just East of the Suwanee River, with my son Alex. We had been moving slowly, observing the abundance of wildlife including armadillo quadruplets (always identical, they roam and play together when young) and a large Gopher Tortoise. At one point we stopped and watched a large Barred Owl in a nearby tree, as it rotated its head to survey the area. Our observations were interrupted briefly by the passage of some VERY NOISY hikers, complaining loudly that they had not seen any animals that morning!

All owls are fully protected by both State and Federal Statutes. Be sure to give these animals their due respect as you observe them, and in doing so you may discover the wonderful, varied voice of the haunting 'Bard.' Also, check out this web site for some great recordings of Barred Owl vocalizations: http://home.centurytel.net/bobowlcalls/Barred_Owl_calls.htm#eight_note.

Monday, October 15, 2007 (November 2007)

The Air that We Breathe

Thermophilic green algae near a mineral deposit in the heated (100-133°F) water of Whirligig Geyser in Yellowstone National Park. Photo © Jon Garvin, use subject to a Creative Commons Attribution 2.0 Generic license.

I recently heard that an instructor responsible for a course in Tropical Marine Ecology (Marine Biology) had dismissed bacteria in his review of important marine organisms. This concerned me, as I was aware that recent research suggested a very important role for bacteria in marine ecosystems. A quick review of recent literature revealed that one group of cyanobacteria in particular, the minute *Prochlorococcus*, accounted for as much as 80 percent of photosynthetic activity in seawater. Years ago, biological oceanographers did not have the tools to collect and study the minute, almost sub-microscopic creatures that passed through their sampling nets. Recently, however, extraction of DNA samples from seawater has indicated the presence of an enormous, diverse array of marine bacteria, far outnumbering the diatoms and other larger single-celled forms. This remarkable result parallels recent studies that have revealed many of the important links between human digestion and our own internal population of more than 400 varieties of beneficial, *symbiotic* bacteria.

Now, if photosynthetic marine bacteria play such a large role in the primary productivity of the oceans (based upon their ability to capture the energy of sunlight), it follows that they play a large role in the production of the oxygen that we breathe. It appears now that these bacteria account for nearly half of our oxygen, the other half coming from terrestrial, vascular plants. In the marine environment, almost all primary production is the result of these microscopic forms, in turn eaten by protozoa, which are in turn eaten by small crustacea, fish, and so on. In other words, larger creatures eat smaller creatures. In contrast, the primary producers on land are often the *largest* creatures, the vascular plants including trees, and these are eaten by a host of *smaller* creatures.

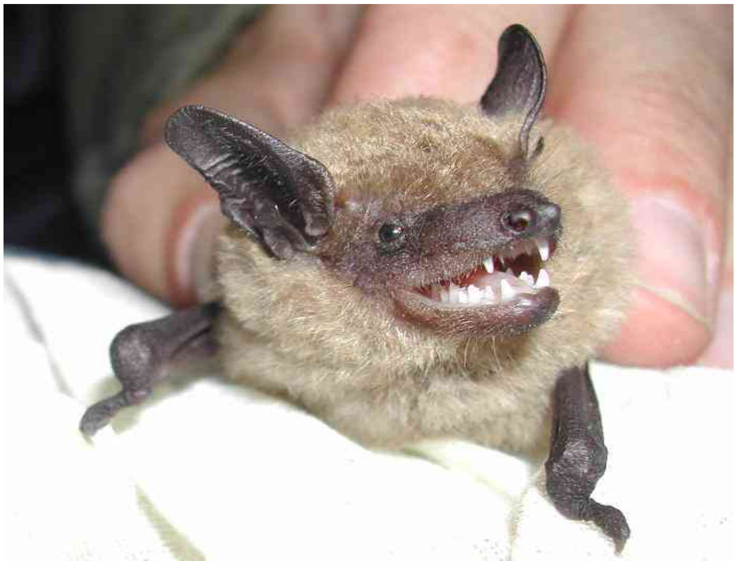
Only about 21 percent of our air consists of oxygen. Most of the air is comprised of nitrogen (78 percent), with a smaller amount (less than 1 percent) of the inert gas, Argon. The water vapor (humidity) of air varies greatly, but is less than 1 percent. We hear a lot about carbon dioxide and global warming these days, but carbon dioxide (the source of carbon for most life) accounts for only about 3/100 of 1 percent of our air. Other gases (neon, methane, helium, krypton, hydrogen, and xenon) are present in much smaller quantities.

Of all of these gases, oxygen is the most reactive. That is why we need it to burn our food and our fuel, to energize both our bodies and our automobiles, respectively. Oxygen is abundant in the thin outer crust of the earth, and in fact comprises about half of the mass of both our mountains and our plants! It comprises almost 90 percent of the mass of all water on this planet. Because of its extreme reactivity, most of it is tied up a variety of silicates and oxides (think *rust*), however, and free (diatomic) oxygen would not be available in our atmosphere without the work of the microbes and plants that can literally split water molecules to release free oxygen.

About half of the oxygen production of the Earth comes from the ocean, and about half from terrestrial environments. Forests and swamps are at least twice as productive as grasslands and savannas, and account for about 3/4 of terrestrial oxygen production. However, because much of the oxygen produced by terrestrial plants is consumed when they are burned or decomposed, it is thought by some that as much as 90 percent of the new oxygen contributed to the environment comes from the marine environment, to counter removal of oxygen through geologic processes of oxidation. A human being consumes about 400 pounds of oxygen per year, on the average. Use of 1,000 gallons (about 6,000 pounds) of gasoline in a vehicle can consume another 12,000 pounds of oxygen! A large tree can produce about 250 pounds per year, so two large trees might support the oxygen needs of one person, without any machines. In fact, it has been estimated that a mature tree can produce about $30,000 worth of oxygen over a 50 year span. Of course, we know that the value of oxygen is much greater than any dollar amount. It is life itself. There are many organisms (microbes) that could (and do) live on this planet in the absence of oxygen, but we are not one of them! We, and *to an even greater extent* our many oxygen-consuming machines, are increasingly important factors in the oxygen cycle of our home planet. Even as they rust, our machines consume oxygen.

Monday, November 11, 2007
(December 2007/January 2008)

Bat Life at Neely Farm



Close-up of Big Brown Bat (*Eptesicus fuscus*), courtesy of USGS Western Ecological Center.

If you like to take those long twilight walks on one of our warm and humid summer nights, you have most likely seen the larger, fast-flying Red Bat (*Lasiurus borealis*) dipping and diving, or the smaller Evening Bat (*Nycticeius humeralis*) circling high in the sky. You may also see the heavier Big Brown Bat (*Eptesicus fuscus*) in open areas, or the smaller, circling Eastern Pipistrel (*Pipistrellus subflavus*) near water, in open woods. Of the 14 species of bats known to occur in South Carolina, only these four are common in the Piedmont Region, although eight other species have been observed on occasion. At all times of the year, these bats (*Chiroptera*, or hand-wings) live with us at Neely Farm. On colder nights, rainy nights, or short winter nights, however, they are hidden from our view in their roosting sites or hibernacula.

Bats are amazing mammals. Our bats are nocturnal, and prefer to hunt in the warmer hours of the night when their insect prey is active, beginning about 15 minutes after sunset. In the darkness, they avoid obstacles and find their insect prey (all kinds of flying insects, including beetles) by means of echolocation, until they are "full" and return to the roost. They emit high-pitched sounds though their mouths and recover reflected sounds, as well as sounds produced by their prey, with their large ears. They can separate the output from the input frequencies, and build a remarkably detailed picture of their surroundings from this information, much as we use vision.

Like us, bats are mammals. The males mate with multiple females in the late summer and fall, but gestation (40-60 days) does not begin until spring. The males live alone, or in "bachelor colonies," but many (15-700) females can be found in brood colonies. Most bats have only one "pup" each year, but all of our bats except the Red tend to have twins, and females have two mammaries to accommodate them. The Red, with four mammary glands, is exceptional, and can have a larger litter. The newborn pups are usually blind for about a day, but can weigh in at as much as 50 percent of the female's weight at birth! Only the females tend to the young, and may eat their body weight in insects every day in order to feed them. They recognize their own young by scent or by the calls that they make, and will rescue their crying young if they fall from the day roost. In fact, they frequently carry their young between roosting sites. The young grow quickly, and may fly and feed on their own only 3-5 weeks after birth.

Our larger bats (Big Brown and Red) may live up to 19 years in the wild, if they can find a place to live in the first year. The smaller bats (Eastern Pipistrel and Evening) may only live 2-8 years. In northern areas, these bats generally migrate southward to hibernate, but they overwinter here. Hibernating bats can tolerate very low body temperatures, a few degrees above freezing, and their heart rates drop drastically. They lose about 25 percent of their body weight in the process.

You may have put up some bat boxes, of varying size, in your yard. All of our bats, except the Red (perhaps), can greatly benefit from these. Most require crevices one inch or less in width, and placement at least ten feet above the ground, on trees or on buildings. Some species like direct sun, others like shade, but exposure of the boxes to some amount of morning sunlight is associated with greater success in getting bats to move into these boxes.

Housing is critical to survival of bats, so you probably wonder how they do it in the absence of bat boxes. For each of our species, the summer daytime roosting spot tends to differ from the overwintering, hibernation site. The Big Brown and Eastern Pipistrel like human structures, but will use hollows in hardwood trees as daytime roost sites during the summer. They frequently hibernate under houses, or in storm sewers or culverts. The Evening Bat also hibernates in buildings, but prefers tree cavities in longleaf pine stands during the summer. The Red lives throughout the year in forested areas, near the crown of trees.

Bats are remarkable creatures that greatly benefit us through their consumption of flying insects. A colony of only 100 bats may consume as many as 1.25 million insects in a single season. At the same time, they often get a bad press. Two things are important to remember in this regard. First, there are no Vampire Bats in this area, and the ones that do exist are confined to a few tropical areas. There have been occasions when lack of knowledge about the rarity of rabies, and the low frequency with which it is carried by wild bats (when compared to other mammals) has created a "bat panic." Rabies itself is exceedingly rare in the United States, and your chances of getting it from a bat have been estimated at about 1 in 150,000,000. At the same time, if (by rare chance) you come upon a bat that is not behaving normally (for example, it allows you to approach it), do not pick it up with unguarded hands. This is just common sense.

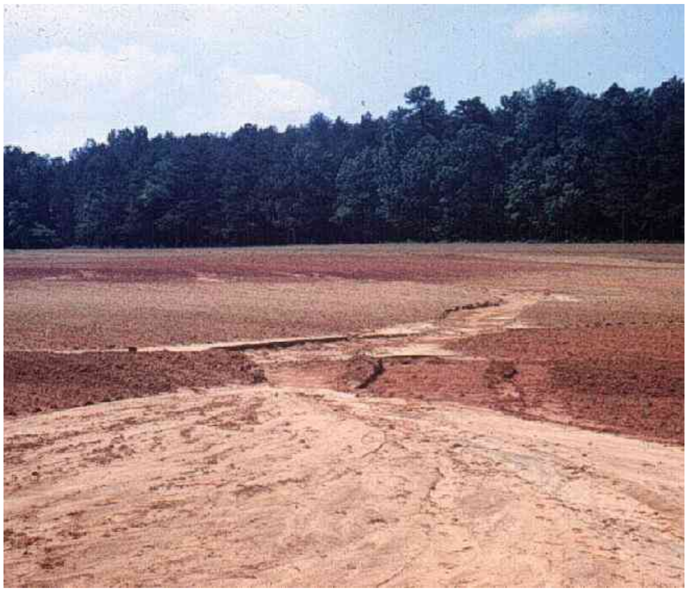
At the same time, continue to enjoy the twilight flights of our local insect-eating bats in the warmer months of the year, as they swoop, dive, and circle. Many tropical bats feed on fruits, and pollinate flowers. You may see some large forms ("Flying Foxes") at the Riverside Zoo in Columbia (Free admission with a membership in the Greenville Zoo!).

Wednesday, January 16, 2008 (February 2008)

Top Soil (A Brief Upstate History)

Through much of our history, civilization has been dependent on local agriculture for its survival. As surface soil eroded and washed away under agricultural pressure, food-growing came to a halt, and local settlements disappeared. In many parts of the world, native forests have been subjected to "slash and burn" destruction by nomads intent on obtaining only a few years of agricultural production, before they moved on.

Barren red earth, virtually devoid of top soil, is often encountered in Upstate South Carolina. New housing developments in our own area of Greenville County usually begin with the clear-cutting of vegetation and remaining trees, and the use of huge earth-movers to level and scrape the earth, leaving a barren red surface on which houses are erected, and thin layers of fresh sod are laid out.


Erosion in a Piedmont agricultural field. Courtesy of Northwest College Agriculture, use subject to a Creative Commons Attribution 2.0 Generic license.

It may come as a surprise, then, to learn that the native soils of the Upstate were once very rich and loamy, largely the product of mature oak-hickory forests. Remnants of this forest land still surround us, in marginal or otherwise protected areas. Some local forests have stood for more than 100 years, but few trees yet qualify as "old growth" in the sense of a forest that has been allowed to live out its life, uninterrupted by clear-cutting. Many Upstate areas, including the extensive Clemson Experimental Forest, are only now (since the Great Depression years) recovering from an era of extreme erosion. In the not-too-distant past, the Clemson Experimental Forest looked more like an open pit mine than a forest!

Going back in time, we know that native Indians burned the forest undergrowth to clear land for their agriculture, and to provide habitat for game species. By the time that European colonists arrived to practice a more intensive form of agriculture, there were already many open savanna-woodland areas alternating with deep forest. Over time, more land was cleared and settled for farms. This continued up until the post-Civil War era, when intensive destruction of soils led to the widespread abandonment of ruined farm lands. A very large part, at least 40 percent, of the Piedmont region of South Carolina was lost to *all* agriculture as a result of single-crop farming of coarse upland cotton, employing the great majority of the people in this region under a system of poor tenant farmers working on small acreages. Land was even cheaper than poor labor, and thus growers cared little about the loss of soils and soil nutrients and they moved from plot to plot. A misplaced Scottish/Irish practice of plowing furrows up and down the hills (!), combined with plentiful rainfall in this region, led to even greater erosion. We still see the results of this erosion in our local creeks, after a heavy rainfall.

Ironically, the Federal Government introduced the now-dreaded *Kudzu* to provide needed feed for agricultural animals in this impoverished landscape, and to control the widespread erosion! We also live with this legacy.

Healthy soil is a mixture of clay (holds water), sand (supports drainage and aeration), and many compounds (including organic or carbon-based compounds) associated with the decomposition of living things. Clay and sand come from the breakdown of underlying bedrock layers on slopes, or from deposition in bottom lands. The accumulated organic content that supports a wide variety of soil life is obtained primarily from falling leaves and branches in a mature forest. Just as plants pull in carbon from the air to add to the richness of the soil, bacteria in the soil assimilate nutrients from the air (nitrogen) and from the underlying bedrock (minerals) to support all forms of life. Bacteria and a host of other soil organisms recycle all nutrients. *Over a long time*, soil can recover if given the opportunity.

Neely Farm is a mixture of natural with artificial soil types. At one extreme, we have some areas where fallen leaves and branches are removed annually from slopes barren of soil, slopes left to erode in our heavy rainfall. In other areas, our lawns may carry only the soil that was brought in as sod. As we tend to remove organic material (including clippings and fallen leaves) from managed lawns, some homeowners choose to replace this sod periodically, after it deteriorates. Some homeowners haul in mulch (including pine needles, bark, and shredded wood) to serve as a kind of soil around their plants.

At the other extreme, many areas in Neely Farm are left to develop as native woodlands. Because the developers of Neely Farm did not clear-cut all areas, many of us have some relatively healthy top soil, and grand native trees, in at least parts of our lots. Close your eyes, and dream back to the days when this was a land of woodlands and savannas, great old trees and prairies rich with deer and wild turkey. We are fortunate that parts of this great, living world can still be found!

Wednesday, February 18, 2008 (March 2008)

Neely Farm Bedrock

Shiny crystals of Muscovite (Common Mica) in subsoil gravel formed by the breakdown of underlying bedrock. Crystals of this large size grew slowly in superheated rock, over many millenia.

As residents of Greenville County, we are "officially" inhabitants of that great region known as Appalachia, defined as much by its culture as by its geology. As for culture, I hope that you all enjoy, as I do, our distinctive *Bluegrass* and other folk music! However, let's focus on the geology here. We live in the *piedmont* (French for "foothills") of that great range. We may not have great mountains in our backyard, but we do have some fine hills to climb.

And, we have bedrock. Under our houses and our lawns is bedrock, often breaking down into clay-sand and soil near the surface, but bedrock nonetheless. In South Carolina, layers of bedrock are stacked on top of eachother, with the older layers exposed by the process of uplift and erosion to the northwest, and the younger layers of sediment still being deposited toward the southeast. The bedrock at Neely Farm is part of the Six Mile Thrust Sheet, one of a series of *thrust sheets*, separated by faults, that were originally deposited as sediment (with some igneous or volcanic rock) on top of the *five* Blue Ridge Thrust Sheets. These are called thrust sheets because they have moved independently along the fault plates that separate them. The Blue Ridge Stack includes (from bottom to top, or from oldest to newest rock) the Great Smoky Thrust Sheet, the Hayesville Fault, the Helen Thrust Sheet, the Shope Fork Fault, the Young Harris Thrust Sheet, the Altatoona Fault, the Tallulah Falls Thrust Sheet, the Dahlonega Fault, and (at the top of the Blue Ridge) the Richard Russell Thrust Sheet. On top of this is the Inner Piedmont Thrust Stack, comprised of (again, from bottom to top) the Chauga, Walhalla, Six Mile, Laurens, and Paris Mountain Thrust Sheets. These are separated by four unnamed faults. At the surface here, we have the Six Mile Thrust Sheet. If you drive a few miles, to Fountain Inn or Laurens, the younger Laurens Thrust Sheet is exposed. At Laurens, the Six Mile Sheet found near the surface at Neely Farm is also present, but far below the more recent rocks of the Laurens Sheet.

All of these sediments (as well as some of the igneous products of active volcanos) were deposited in level strata or layers, over a long period of time, between 650 and 400 million years ago (late Proterozoic to early Phanerozoic). Buried deep in the Earth under tremendous heat and pressure, they were all subjected to a process of compaction and recrystallization known to geologists as *amphibolitic Phanerozoic metamorphism* over the last 500 million years (the Phanerozoic era). If you already know what an amphibolite is, more power to you! In any case, these rocks were greatly changed by the process.

As you move from Laurens down toward the low country of South Carolina, the exposed rocks continue to get younger. Above the fall line near Columbia, you can find Mesozoic (age of dinosaurs) rocks. As you move from there to the coast, the exposed rocks get progressively younger, and there are many Cenozoic (age of mammals, extending to the present time) fossils to be found.

You may have heard that the Appalachians are very old mountains. Well, at least they were. David Prowell with the USGS in Atlanta has found good evidence that the ancient Appalachians no longer exist! These ancient mountains were forced up to heights greater than those of the present-day Himalayas, reaching their peak during a collision between North America and Africa (corresponding to the *Anti-Atlas Range* in present-day Morocco) near the center of the supercontinent *Pangaea* about 300 million years ago. About 250 million years ago, the plates started to pull apart, and the ancient Appalachians eroded and disappeared over about 100 million years after that. Beginning about 140 million years ago, the force of the spreading Atlantic Ocean floor, pushing against the North American plate, began to raise the *new* Appalachians, at a rate of about 100 feet (or 30-40 meters) per million years. This continues, at a rate described by John Dennison at UNC (Chapel Hill): *as fast as a finger nail grows*. Not a lot as mountains go, but enough to offset the effects of erosion and maintain the Appalachians at their current height. So the Appalachians that we see today are not ancient, but are comparable in age to the Rocky Mountains of the west.

Any recent evidence of this continuing movement? Yes! In 1883 an historic earthquake of magnitude 7.3 killed about 60 people in the Charleston area. It was followed by about 300 aftershocks over the next 15 years. In Greenville county, we live between the two largest epicenters of earthquake activity in the United States, one near Charleston, and the other in southern Missouri, near Cairo, Illinois. The probability of seismic activity is much less in the Piedmont than in either epicenter, but much greater than it is throughout most of the Eastern United States.

The best place to find interesting rocks in Neely Farm is along the bed of Rocky Creek (well-named!). This is a sedimentary area, with many feet of recent sediment in the flood plain surrounding the creek. Much bedrock is exposed along the creek bottom, but most of the rocks that you will encounter have been transported from areas far away, higher up in the Appalachians. You can find sedimentary sandstones, igneous basalts, and recrystallized quartzites or mica-bearing rocks here. If you have a microscope available, you will find that the sand of this creek bed reveals a similar diversity of composition. These are present-day (*Holocene*) sediments comprised of fragments of the ancient mountains. Far downstream, this sediment will one day form the concretions and sandstones of newer rock formations.

Wednesday, March 19, 2008 (April 2008)

Cats Feral and Domestic: Our Friends, and Predators at Large

African Wild Cat (*Felis sylvestris lybica*). Photograph courtest of Ramon Cunha, use subject to a Creative Commons Attribution 2.0 Generic license.

Various forms of the African Wild Cat, *Felis silvestris lybica*, have been associated with human beings (as *the cat*) for at least 9,500 years, perhaps by their own choice. The ancient Egyptians mummified cats, to accompany them in the afterlife. *Felis silvestris* is widespread in nature, found in many parts of Asia, Europe, and Africa, but all of our "domesticated" cats are now known (through detailed genetic studies) to be descendents of the North African to Middle Eastern variety of this Wild Cat, also known as the Desert Cat. Where domesticated forms of this cat live near wild forms, they interbreed freely.

In nature, as in domestication, African Wild Cats tend to hunt at twilight, and in the nighttime. Their forward-facing reflective eyes have many black and white receptors, very effective for stalking prey at night. These are visual predators. Most of the social life of cats is also primarily at night. These cats are *solitary hunters* that feed primarily on any mammal that they can catch, primarily rodents, but they also feed on reptiles or birds where these are available. With their soft foot-pads and retractable claws, they are stealth predators, quite unlike the wolf (*Canis lupus*, also a domesticated carnivore, a *pack hunter* popularly known as *the dog*), which generally runs it prey to the ground after a long chase. Both males and females defend territories from other members of the same sex, but the territories of males overlap with those of females.

The many domesticated forms of cats (and dogs) are due to what some people like to refer to as *breeding*, or what biologists refer to as *inbreeding*. The extent to which wild appearance, form, and behavior ("instinct") has been retained through this process varies greatly by breed. When cats escape and revert to their wild ways, they are known as *feral* cats.

In South Carolina, we once had two native cats (*Puma concolor*, also known as the Puma, Mountain Lion, or Cougar, and *Lynx rufus*, the Bobcat). Pumas are very rare, and tend to feed on larger animals. They are also dangerous to humans and domesticated carnivores like cats and dogs. It is very unlikely that you will ever encounter a Puma in Eastern North America, however. They are probably extinct in South Carolina. Bobcats are about twice the size of the African Wild Cat ("house cat"), about 10-28 pounds in weight, and prefer to feed on rabbits and hares. They also feed on rodents, but are very strong and agile and can attack and kill much larger mammals, including adult deer. In the wilder parts of South Carolina, they are not uncommon. In the past, they were hunted for their fur, and populations were severely reduced. Now, their main problem is loss of habitat (male territories cover 25-30 square miles!). Chances are, you will never see a Bobcat. This is not because they are rare, it is because they are only active during hours of twilight and dawn and they are very careful about being seen.

Feral cats, like native cats, have to hunt for their prey, and they cannot survive in an area if prey populations are reduced to a low level. Thus they require large territories. *Free-ranging domestic cats*, however, can live in high densities in a neighborhood because they are *subsidized by their owners*. After all, these predators are our friends and companions. Their tendency to prey upon local wildlife is *just their nature* (as we like to say), but their high population density is not! As a result, if allowed to roam free, these cats can decimate not only our local chipmunk populations, but also our song bird populations. Although song birds are protected by law, free-ranging cats stalk and kill many millions of them every year in the United States.

It is not uncommon for Neely Farm homeowners to allow their domestic cats to free-range in the neighborhood. Apart from the Greenville County Ordinance that prohibits running domesticated animals *at large* (off of your own property), there are plenty of reasons to stop this practice. Clearly the protection of wildlife, including song birds (Cardinals, Blue Jays, and Carolina Wrens are particularly vulnerable), is an important issue. A single free-ranging cat can kill hundreds (up to a thousand, by some studies!) of local birds and mammals each year. Free-ranging cats typically live only 1-5 years, compared to 15-25 years for companion cats secured by their owners. They are subject to a host of communicable diseases, and pick up fleas, ticks, and mites.

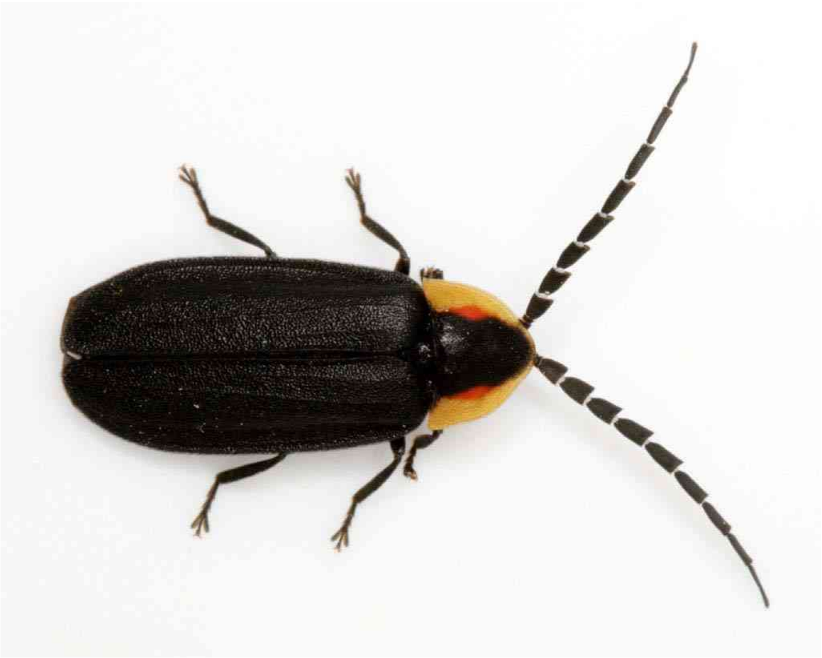
To help safeguard local birds, you should place bird feeders away from cover, where cats can hide. You may need to place animal guards around bird houses, because cats easily find these and wait until their inhabitants emerge or return. You should never feed free-ranging or feral cats in the neighborhood!

I really like cats. I grew up with a family of four cats, and enjoyed their affection as well as relative independence and self-reliance. They are attractive, intelligent, inquisitive, and downright interesting animals to have around. Compared to lions, they come in less-threatening sizes! From the perspective of native wildlife, I am not overly concerned with the fairly large population of feral cats in the Southeast, because I know that these cats will not be able to survive if they decimate their prey populations. Some wildlife organizations, worldwide, are very concerned with the impact of feral cats, particularly in areas that were never inhabited by comparable predators, before cats were introduced. In our area, they are subject to the same population controls as wild species, and may in turn be eaten by other predators. The life-span of a feral cat is relatively short, only a few years at most. The real danger to neighborhood wildlife is the free-ranging domestic cat.

Sunday, April 20, 2008 (May 2008)

Fire Flies or Lightning Bugs?

Well, neither! The insects that flash in the twilight of warm spring and summer evenings are neither flies nor bugs, but beetles. In wet years, they can be abundant. In dry years, relatively scarce. So, where do they come from? Larvae live in relatively wet, moist soil, often under rotting logs or fallen bark, or under the bark of trees. As larvae, they are active predators, often with hollow mandibles to suck the juices of the snails, slugs, or insects that they feed upon. In wet seasons, this prey is abundant- hence more fireflies. Most larvae also have glowing lights, and they are commonly called "glowworms" at this stage of development It is thought that the larvae use their lights to warn predators that they are protected by toxic chemicals. After several weeks of feeding, and several more weeks of pupation, they emerge to their adult life as winged beetles. This is when the twilight display begins.



Lucidota atra, a common diurnal (day-active)firefly that does not flash as an adult. Photograph © Patrick Coin, used subject to a Creative Commons Attribution Noncommercial Share-Alike 2.0 Generic license.

Some of the fireflies in our area do not display as adults. The day-active Black Firefly (*Lucidota atra*) is a soft, black beetle with some pink to red coloration on the thorax, probably to warn predators that it is protected by toxic chemicals. The most commonly encountered flashing fireflies here are either *Photinus*, or the larger *Photuris*. Male *Photinus* fly actively but relatively slowly, flashing frequently to elicit a response by a female waiting on the ground or upon vegetation. If a female gives the right response (thought to be measured by a male as the duration of the brief interval between his flash and her responding flash), the male will approach the waiting female.

Female *Photuris* take advantage of this behavior by mimicking the flash patterns of female *Photinus*. When male *Photinus* respond and alight nearby, they are captured by the much larger female *Photuris* and eaten. There is more to this story! It turns out that the *Photinus* fireflies carry toxic steroids called lucibufagens in their blood, and the female *Photuris* are able to devour and then sequester these toxins in their own blood when they feed on the male *Photinus*. This protects them from most of their predators, including spiders that will drop a protected *Photuris* immediately upon contact. The voracious female Photuris have been called *femmes fatales* for their deadly game of seduction.

The ability of fireflies to produce cold light in a narrow visible spectrum (no infrared, and no ultraviolet) is of great interest. In specialized light organs on the abdomen of fireflies, the enzyme luciferase oxidizes the chemical luciferin (a biological pigment) to produce photons of visible light, and an oxidized form of luciferin known as oxyluciferin (Despite its popular religious connotations, the word "lucifer" actually means "light bearer" in Latin!). This process is remarkably efficient, converting about 9/10 of the energy that it consumes into visible light. Other organisms (including some fish, squid, bacteria, dinoflagellates, jellyfish, copepods, comb jellies, shrimps, and many other marine organisms) also produce "luciferins" of varying composition (at least five different classes have been identified) and thereby emit light in a process that is generally known as *biological luminescence*.

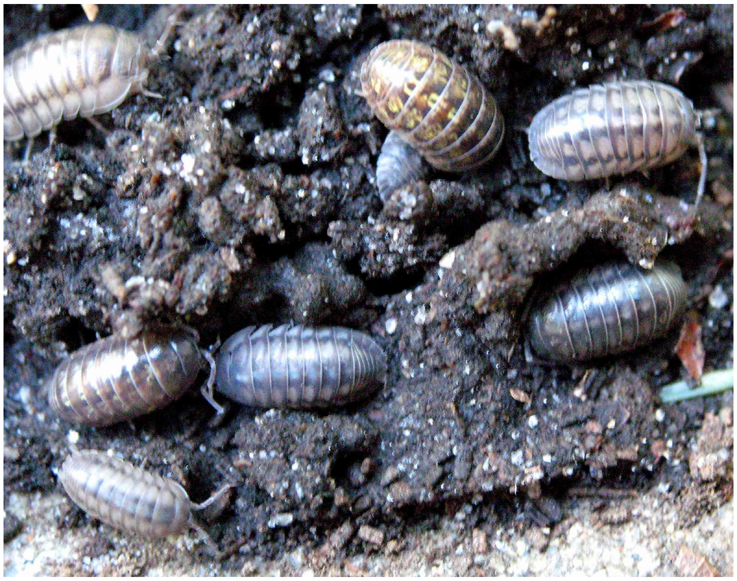
Many areas in the Southeast are locally famous for their firefly displays, often involving the synchronous flashing of thousands of individual beetles in late spring or early summer. These include the Congaree National Park south of Columbia, and several areas around the Great Smoky Mountains National Park. Even if you have read the various accounts that purport to explain the flashing behavior of these creatures, the experience of thousands of flashing fireflies on the move in a large meadow, or along a marshland border, will convince you that there is still a great deal of mystery surrounding the purpose of this behavior! Both children and adults can share this wonder.

To read more about firefly femmes fatales, you can download a related paper from the Internet. This paper also has some good photographs of these beetles: (http://www.pnas.org/cgi/reprint/94/18/9723).

Wednesday, May 21, 2008 (June 2008)

Tiny Armadillos in our Midst

Large Nine-banded Armadillos (*Dasypus novemcinctus*) of the *mammalian* genre are apparently headed our way. They already thrive in the low country of South Carolina, and the Upstate is definitely included in their likely future range. They reproduce quickly; each litter consists of exactly four quadruplets, all identical. When we go hiking in northern Florida in the summer, I like to look for these roving foursomes at play in the underbrush.



A happy bunch of *roly-polies* at Neely Farm. There is at least one *Armadillium vulgare* in this picture.

You may not know it, but we are already surrounded by vast numbers of *tiny* armadillos, of the smaller *crustacean* genre. Abundant in soil, leaf litter, and under logs or rocks, these harmless creatures are affectionately known to children as *roly-polies*, *sow bugs*, *pill bugs*, or *armadillo bugs*. They feed on detritis and decaying plant materials, and make great "first pets" that will also feed readily on raw potatoes or apples. Scientists know these as either *terrestrial isopod crustacea* or *oniscids*. There are more than a hundred kinds found in the United States. Like armadillos, many can *conglobate* ("roll into a ball") to protect their soft undersides.

Many of the most common ones in our area are placed in the genus *Armadillium*, or possibly *Porcellio*. Both names suggest the role of their hard, protective plates. If you want to know why your garden leaves or mulch pile disappears so quickly, these animals are a large part of the answer. They cannot digest the cellulose in leaves directly, but rely on a host of endosymbiotic bacteria in their gut to accomplish this [Nothing unusual here, about 90 percent of the cells in our own bodies are *endosymbiotic* bacteria that facilitate our own digestion!].

Roly-polies are not insects, but are in fact crustaceans related to lobsters and crabs. Although they live on land, they still rely on their gills to breathe (although these can be modified with small tracheae), and they tend to congregate in moist places where they will not dry out. Most (but not all) have seven pairs of very similar legs, hence the name Isopoda for the group (iso means "same," poda means "legs"). Isopod Crustacea are common in marine and freshwater habitats, and I have actually held one gigantic, colorless *benthic* (deep-sea-bottom) species close to one foot (25 cm) in length, in my hand! These are some of the most abundant animals in deep sea habitats. One, *Bathynomus giganteus*, can even grow to a length of 50 cm (about 20 inches). Like insects, isopods have *unstalked* compound eyes. They have one pair of antennae, and four pairs of jaws or mouthparts. All female isopods, whether aquatic or terrestrial, carry their young through development in a brood sac under the abdomen, from which they emerge as fully functional miniatures of the adults.

Apart from "terrestrial" crabs in the tropics (which nonetheless require access to water for their reproduction), isopods represent one of the great success stories of Crustacea on the land. The major crustacean success story, of course, belongs to the insects, only recently "rediscovered" as terrestrial crustaceans. For a long time, insects were not thought to be closely related to other Crustacea, but they are now grouped with them in a larger group called the *Pancrustacea* by scientists. If you are even half my age, you probably learned nothing about this when you were in school!

Back to the roly-polies at Neely farm. How many kinds do we have here? Of the hundred-odd species found in the United States, I just don't know how many are found in South Carolina. Some familiar forms, like the common and colorful *Armadillium vulgare*, were introduced from Europe, and now have a worldwide distribution. There may be other forms that are unknown to science, as few people study these animals. If you are curious, you can even make a project out of determining how many forms you can find in your backyard. This would also make a great student project for school. Here's a good web site for further study, including many links: http://tolweb.org/tree?group=Isopoda&contgroup=Peracarida. Good hunting!

Sunday, June 15, 2008 (July/August 2008)

Beavers, and Other Rodents at Neely Farm

Beaver (*Castor canadensis*). Photo courtesy of Magnus Manske/Wikipedia. Use subject to Creative Commons Attribution Share-Alike 2.0 Generic license.

There are really many different rodents living with us at Neely Farm, but we seldom see most of them. There are at least 28 different rodents (Rodentia) known from South Carolina, and many of not most of them can be found in our area. The most diverse and abundant groups are the field mice or deer mice, genus *Peromyscus*, and the voles, *Microtus*. When you see hawks circling above the soccer field, or foxes exploring along the woodland margins, it is possible that they are hunting for these small rodents.

The rodents that you are most likely to encounter are all members of the squirrel family, Sciuridae. These include our only chipmunk, the Eastern Chipmunk (*Tamias striatus*), and the ever-present Eastern Gray Squirrel (*Sciurus carolinensis*). We also have flying squirrels in the woods (*Glaucomys*), but these small, attractive gliders are quite elusive and it is unlikely that you have seen them. We live at the extreme southeastern limit of the range of the Eastern Chipmunk (hard to find south of Greenville County!), but they seem to do well here, as long as they can find a safe place for their burrows (preferably sheltered and hidden under brush). You can think of chipmunks as ground-dwelling squirrels. The Eastern Gray Squirrel usually gathers dried leaves together to build its nest high up in a tree, but sometimes finds (or makes!) an entry into our attics for this purpose. These are very inquisitive animals, always on the lookout for new opportunities. We installed a series of progressively more challenging "squirrel-proof" bird feeders in our backyard, the last a fancy import from faraway Wisconsin (where they should know squirrels!), until we finally gave up on the notion of "squirrel-proof." I marvel as a squirrel swings off the weight-bar that is supposed to protect the seeds, and deftly flips out one handful of seeds at a time during the height of its swing. Yes, squirrels, like many rodents, have *little hands*. I'm sure you have had similar experiences with these creatures. In nature, these squirrels are really very important, the *chief agriculturalists* of the oak-hickory forest, burying their caches of acorns and pignuts all over the place. They really don't remember the specific location of each nut or acorn, so many of these seeds live go to germinate and to become the tall trees that define our forest. This is how the forest grows.

Our largest rodents, however, are aquatic. Like our mice and voles, they are placed in the family Cricetidae. You made have seen the smaller Muskrat (*Ondatra zibethica*) swimming at the surface in the Neely fishing pond. Muskrats swim with laterally flattened tails, and dig burrows (often of surprising size) under the banks of lakes and quiet rivers. Muskrats are most active from dusk to dawn, and they can chew aquatic plants when they are underwater. If you are quiet, you can usually observe them at dusk.

The largest rodent in North America, and the second-largest rodent in the world (second only to the South American Capybara), is the Beaver (*Castor canadensis*). Although largely trapped out in Upstate South Carolina by European settlers, they are now on the comeback. We presently have several living in Rocky Creek, upstream from a dam that they have constructed. Beaver are primarily active at night, so it is unlikely that you have seen them. They are very wary of humans (and their dogs), for good reason. You are probably familiar with the appearance of beaver lodges in other parts of the United States, but you will not see these here. In the Piedmont, Beaver dig their large burrows into the banks of streams, with concealed underwater entrances. The most obvious sign of their presence comes in the form of chewed logs, stumps, or branches, where the signs of their paired incisor teeth are clearly visible.

Like all rodents, Beaver have large incisors that keep growing, and *they must chew*. They prefer to feed on the soft, green tissue under bark, and seek out stands of saplings with accessible branches. Beaver can also kill large trees, by stripping or girdling all accessible bark, or by felling them. Until you have seen a stand of trees, each greater than two feet in diameter, cut down overnight by a family of beavers, you may not understand what they are really capable of. Beavers, more than any other rodents, engineer and maintain their own environment. In areas with flowing streams but no ponds, they build dams and make ponds. In older woodlands with few small trees, they make stream-side clearings where saplings can thrive in the sunshine. At the same time, the habitat designed by beavers controls both flood and erosion, and supports a wide variety of wildlife, including water fowl and panfish (or sunfish). Behind the recent dam on Rocky Creek, you can already observe nesting sunfish as well as a few Smallmouth Bass. Today most of the lakes in our area are really man-made reservoirs, but at one time beaver-made lakes ran in chains, up and down every stream in the Piedmont, supporting a wealth of aquatic wildlife. Early European travelers, like the native Cherokee before them, thought this one of the most beautiful places on Earth!

Sunday, July 20, 2008 (September 2008)

The Intelligence of Wasps

Large *Vespa* wasp drinking sap from a tree in Neely Farm.

As I walked across our patio last week, by accident I startled a dark-black digger wasp as it dragged the remains of a all-too-large wolf spider (*Lycosa*) along the ground. All of the unfortunate spider's legs had been cut off by this wasp, but it was still too heavy to carry in flight, so the wasp had to drag it. I backed off, and after a few moments of hesitation the wasp began to look for the valuable prey that it had dropped several meters away. It walked more or less toward the prey, in a zig-zag search pattern, and found it in less than a minute. The wasp then continued to drag its spider *directly* toward a retaining wall built of treated lumber, at least 12 meters away. This was accomplished in a matter of minutes, and the wasp quickly ascended the wall, stopping at about the third level of timbers. Here the wasp set the spider aside temporarily, and tried to wedge itself into a crack. This was futile, as this place was just too narrow. After a few minutes of futile effort, the wasp carried its prey up two more levels, and promptly found its burrow, and disappeared into it. The site of this burrow was marked by recent diggings, a pile of small soil particles of the size that a digger wasp would carefully excavate in advance, one by one, to prepare a place for its young. After excavation, the wasp would have begun its hunt, with the inevitable result that I observed.

Digger wasps are solitary, voracious predators, often iridescent and otherwise very colorful, if only in warning colors like bright red and shiny metallic purple. But, like most other wasps, you can often find them at the nectaries of flowers in your garden, or in an old field area. Honey bees get all of the protein that they need for their young from pollen, but wasps must hunt either insects, or spiders, or both. Another common solitary wasp that you may encounter at your flowers is the potter wasp, which builds a separate wonderfully round, small clay pot for each of its young. Each pot is built at a separate location. These pots have the same shape, including circular, drawn-out lip, as the classical pots of India. You may also find potter wasps, or the unrelated mud daubers, at patches of bare clay near your sprinklers, when they are gathering mud. I once followed a potter wasp as it made a "bee-line" across an open field, and landed at the base of a clump of goldenrod. It then scurried up a sand bank under the goldenrod about 1 meter until it came directly to a pot that it was still working on, and promptly proceeded to add to this pot with a small piece of mud that it had been carrying. As Konrad Lorentz demonstrated many years ago with the honeybee, wasps have a remarkable ability to remember places, and a remarkable sense of direction as they navigate. The largest of all wasps in our area is a solitary form known as the Cicada Killer, which looks like a giant hornet (more than 3 cm in length). Sometimes you may see these flying by, carrying full-size cicadas that they have captured. They have to be large to do this.

Most of the wasps that you encounter are social wasps, generally living in colonies where all workers are sisters. These wasps often build their homes with a special kind of paper that they manufacture, as do honeybees. This includes both paper wasps and several varieties of hornets (smaller yellow jackets, bald-faced hornets, and the introduced *Vespa*, a real giant at nearly an inch in length). The other social wasps that you may encounter are mud daubers, and these build with mud that they collect. All feed their young on captured insects and spiders. Although often feared because of their venomous sting, generally they will not attack humans unless threatened, and they may defend their territories against less-welcome insects.

Wasps may be small, compared to us, but their behavior is very sophisticated. They process a lot of information. At one time, it was popular to distinguish between *instinct* and *intelligence*, the latter associated with *human* behavior. Scientists don't do this any more. We have all learned a great deal about intelligence from computers and computing, and can now appreciate that a lot of programming can be placed into a small package. We talk about *sensory input*, *information processing* and *information retention* with respect to animal behavior, and wasps do a great deal of these. We talk about *behavioral modification*, or *adaptive responses* in behavior, and wasps have a lot of these too. There are many books that you can read on the subject, but you should really *just watch them*. I can assure you that you have never seen a zoo-full of animals so intriguing as these humble creatures, as they go about their lives from the dawn to dusk cycle of one natural day to the next.

Monday, September 15, 2008 (October 2008)

Biocides

Colorful fungal hyphae under pine bark. Fungi are well-protected from attack by other microbes, Photo by Kim Fleming, use subject to a Creative Commons Attribution Noncommercial Share-Alike 2.0 License.

Biocides are chemicals that kill or maim living things. From the news media, you would think that chemical warfare was something new. Actually, chemical warfare is a *way of life* for many of the bacteria, plants, fungi, and animals that inhabit Neely Farm. My dear friend Thomas Eisner (Cornell University) recently wrote two very-readable popular books (*For Love of Insects*, and *Secret Weapons*) that highlight some of his many life-long studies of the chemical defenses employed by insects and other arthropods. These include otherwise harmless millipedes that produce deadly hydrogen cyanide gas, a variety of benzoquinones, polyzonamines, buzonamines, and quinazolinones. Also included are cockroaches that secrete hexenals, acroleins, benzoquinones, terpineols, and dodecenols, earwigs that spray their attackers with various benzoquinones, termites that aim a spray containing a cocktail of chemicals (including pinenes, limonenes, Trinervitene, and Kempane) at their enemies, stick insects that produce Quinoline, Indole, Naphthaline (active ingredient in moth balls), Anisomorphal, and Nepetalactone, bugs that are protected by an array of vertebrate hormones or steroids (including Progesterone!), lacewings protected by Skatole, and beetles that can accurately aim a stinging spray of acids, or even *boiling* benzoquinones, in the direction of an attacker.

You don't need to remember all of these names, although some of them may sound familiar to you. They are mostly complex carbon-ring organic compounds, similar to those that we use as either insecticides or herbicides, or just as poisons in general.

Many common *antibiotics*, generally chemicals that kill bacteria, were first extracted from fungi such as *Penicillium*. These are compounds used by the fungi to protect themselves. One of the great dangers associated with eating native mushrooms lies in the fact that many species of these fungi contain highly toxic, defensive chemicals (mycotoxins). One, the Rye Ergot fungus, produces a hallucinogenic compound similar to LSD in its effect. Plants of all kinds also produce a variety of deadly compounds to protect themselves, including steroids that are deadly heart poisons (cardenolides), affecting many different animals. Often butterfly caterpillars sequester these compounds from their food plants and use them to protect themselves. Most of these are also complex, carbon-ring compounds.

Many compounds have been introduced into our daily lives to kill plants (herbicides) or animals (insecticides and others). Some, like DDT, were highly effective, but also killed many animals, stopped them from reproducing, or caused deadly developmental anomalies including cancer. After much controversy many of these have been pulled from the market.

There is a current trend to restrict many of the insecticides and herbicides still in use. Many Canadian municipalities, for example, have banned the use of biocides for *ornamental and lawn use* (not absolutely necessary for food production). This is driven in part by the *fact* that many of these chemicals are getting into our ground water, and our drinking water. I worry when I see my neighbors (or hired contractors) spraying biocides here and there, breathing in the fine particles of toxic mist, and failing to mark the sites of their application so that these can be avoided by their young children for the required number of days or months. Do we even inform our own children of the danger of walking on treated lawns?

Well, maybe all of these chemicals that we are applying are really safe after all. Aren't they all approved by the FDA? No! They are not food, and they are not drugs. There is a lot of controversy here. For example, the most widely-used weed killer in North America, Atrazine, has been banned in Europe and it has been associated with sexual abnormalities in frogs (teratogenic) and prostate cancer in humans (carcinogenic). The EPA won't ban Atrazine, but admits that only about 2 parts per billion in our water supply can be toxic to much life. For obvious reasons, we do not test these compounds on humans.

One herbicide used routinely in our neighborhood is RoundUp (R). One reason for its effectiveness is the fact that is is a surfactant, and it readily penetrates organic tissues. Thus, you can apply it directly to the leaves. Glyphosate products have been found to contain a high level of 1,4-dioxane, a highly carcinogenic compound, but this is not reported in the ingredients for RoundUp. The whole area is so rife with uncertainties that there is actually an academic journal dedicated to the subject, called the *Journal of Pesticide Reform*!

We can at least *read the labels*. I pull up a container of concentrated *Bayer Advanced Brushkiller Plus* with *Special Penetrating Formula*, to see what it says. I see that it kills a lot of plants, even hard to kill plants, and we should apply it around our homes, or on walkways. It does warn you to keep people and pets away for a while, and to keep it away from food plants, but nothing too serious here. The active ingredient is Triclopyr (triethylamine salt), however, another carbon-ring compound with *three* highly reactive chlorine atoms around its center. Just when I feel pretty safe about using this stuff, I see some fine print in the corner of the label: *Open...for directions and precautions*. I peel back the label, to find pages of instructions and precautionary statements in fine-print: *harmful if swallowed, inhaled, or absorbed through the skin, avoid contact, avoid breathing, remove contaminated clothing, call a poison control center, do not contaminate water*, etc. If I need to dispose of the product, I should call a local solid waste agency for instructions. The label doesn't claim that that the product is safe, but only says that the Directions For Use are *appropriate*.

I'll be more careful in the future. Next I pull up a container of *Spectracide Bug Stop Indoor Plus Outdoor.* It looks pretty effective, and the instructions only tell me to keep food, utensils, and pets away from this stuff. I guess that keeping the dog and cat outside is a small price to pay for killing cockroaches in the kitchen. One application lasts about 9 months, but apparently this is safe for humans and their pets after it dries. Now I am looking for the fine print, and I find a note in the corner that says STOP and READ THE ENTIRE LABEL BEFORE USE. This label also peels back at the corner, to reveal several pages of fine print. Like the previous pesticide, this one says *harmful if absorbed through the skin, avoid contact, remove and wash contaminated clothing* etc. This label also states clearly that the formulation is *toxic to fish and other aquatic animals.* Almost invisible on the front of the container, I read that the active ingredient is *Lambda cyhalothrin*, but more than 99% of the ingredients are not disclosed.

I checked this out with the Cornell University Agricultural Extension Service (on-line), and was surprised to find that *Lambda cyhalothrin* is a EPA Class II toxin with *restricted use* that can only be applied by *certified applicators*! It also causes the following: corrosion of the skin and eyes, and neuropathy of both the peripheral and central nervous systems! There is no reliable data on just how long it takes for this compound to break down, once applied. The Chemical Name for Lambda cyhalothrin is: (RS) - alpha - cyano - 3 - phenoxybenzyl 3 - (2 - chloro - 3, 3, 3 - trifluoropropenyl) - 2, 2, - dimethylcyclopropanecarboxylate.

I don't remember enough of my organic chemistry to know what all of this implies in terms of danger and reactivity, but I do see evidence of those familiar carbon rings (*benzyl*) here, with reactive chlorine molecules (*chloro*). Well, I'm not a certified applicator, but I assure you that this product is readily available, off the shelf, in local stores. I'll leave you with the one word that the EPA says is mandatory wherever the product is sold: WARNING.

Sunday, October 19, 2008 (November 2008)

Possums at Play in Neely Farm

The photograph shown here, of an adult opossum in winter coat, was taken by Cody Pope. Use subject to a Creative Commons Attribution Share-Alike 2.5 License.

Marsupials are mammals that carry their young in pouches. When born, the tiny young immediately crawl into their mother's pouch, where they continue to grow as they, like all other mammals, suckle. Australia is usually thought of as the homeland for marsupials, with its kangaroos, wallabies, koalas, wombats, marsupial "mice,"and many other exotic forms. However, it is South America that is viewed by *mammalogists* as the ancestral homeland of these creatures, and South American marsupials are generally very primitive. Indeed, these are *the ancient ones* among mammals. Since a chain of volcanic islands (now called Central America) bridged the gap between South and North America, only one, relatively large (cat-sized) species has found its way up to the United States and Canada: the common opossum, the Virginia Opossum, *Didelphia virginiana*, or simply, the *possum*. The original name, *apasum* (or "white animal") comes from the Algonquin Indians. Believe it or not, the name *opossum* was first applied to these animals by Captain John Smith of the Jamestown colony, in 1608!

With agile fingers, opposable thumbs (on its hind feet!), sharp claws, and a long, prehensile tail. our cat-sized possums are well-equipped for tree-climbing, and their dens are usually found high up in trees, in the holes and hollows that they find there. They may also dwell in burrows, under houses, or under brush piles that they build for themselves. They are primarily nocturnal (night-active), so are seldom seen (except as road kill). At the same time, they do not hesitate to visit human habitations in search of rats, mice, garbage, or pet food. Several weeks ago, I surprised an adult in our open garage at night, as it tried to open a plastic container containing pet food. It quickly turned and disappeared into the darkness. Sometimes I hear them feeding in the leaf-litter around our trees at night, searching for worms, snails, and insects. Their five-fingered foot prints are easy to recognize. In Neely Farm, opossums have good reason to fear humans. They are actively hunted in the surrounding area for food, for sport, killed as "pests," or killed for entertainment. Our dogs and cats may also kill them, if they can, although cats generally do not pose any danger to adults. Common yard poisons, used to kill plants, insects, or rats, also kill many. If you place cockroach poisons out in your yard, you may kill opossums. They also drown in open swimming pools. Many forms of our trash, including wire and broken bottles, can be deadly to them.

Possums are *omnivorous*, that is, they eat just about anything that they can catch. This includes grass and other plants, various seeds and fruits, snakes, worms, slugs, insects, birds, and mice. They also scavenge on dead animals, including roadkill (hence their presence on our highways). They do, in fact, *play possum* if necessary, when cornered on the ground by a predator. When they do this, they actually go unconscious, and secrete a foul-smelling liquid. You might pick them up and carry them at this time (a mistake!), assuming that they are dead or injured. They have 50 sharp teeth to defend themselves with, but they tend to threaten or even growl more than attack. They are not aggressive, and they are not good fighters. Possums have a remarkable resistance to the venom of poisonous snakes, and the incidence of rabies in natural populations is very small.

When born (after about 2 weeks in the womb), possums are only a fraction of an inch in size (as many as 20 in a litter!). As they grow, they climb in and out of the crowded pouch, and climb around on top of their mother, clinging to her hair as she hunts. In contrast to their short gestation period, this growth period can last for about 4 months.

A lot of people love possums (The National Opossum Society can be found at: http://www.opossum.org, and the Opossum Society of the United States at http://www.opossumsocietyus.org/opossum.html). Some studies indicate that they are a lot smarter than dogs. Some people like to raise them as house pets (kind of like very intelligent, highly agile and inquisitive, climbing house cats!), but the best thing that you can do for them in South Carolina is really to watch out for them on the roads at night, keep your pets away from them, and (particularly if you have an open swimming pool) give them an alternative water source, such as a bowl on the ground.

Other people *don't love* possums, even though they are really great animals to have around, with respect to their ability to control other pests, including rats and mice. Opossums may be viewed as a threat to berries and other small crops, inciters of barking dogs and bedeviled cats (particularly if these are fed and watered out-of-doors at night), or as unwelcome or untidy guests under our porches. If you don't want possums around, the best thing that you can do is to limit their access to your resources (close that garage door, and that garbage can!), and stop feeding and watering in your yard. By the way, the same thing applies to American cockroaches (*Periplaneta americana*), very common and native to woodlands in Neely Farm. If you take their food and water away, they have to look elsewhere. One reason that I like the possums is that they eat those large cockroaches, and the mice that like to gnaw on wood!

Possums came from South America in the recent past, and their range is continuing to expand, northward. They do not hibernate, however. Possums have a relatively short life-span (1-2 years, or 4 years in captivity), but their versatility and relatively high reproductive rate ensure their continued success. They really do well in the forests, and near the streams of Neely Farm.

Sunday, November 16, 2008
(December 2008/January 2009)

Comeback of the Canada Goose

Canada Goose family facing a strong November breeze in the pond at Neely Farm.

I grew up on a lake in Minnesota with many Common Mallards and the more elusive Wood Duck, not far from the Mississippi River. Common Mallards adapted to a growing human presence in North America a long time ago, but in almost all areas where they occur, Wood Ducks can be hard to find. We were lucky enough, as children, to watch young wood ducks dropping out of their nesting holes in our trees, led by their attentive mother in procession down to the relative safety of a nearby lake. I know of only one place, near the town of Albany in the Willamette Valley of Oregon, where Wood Ducks live unafraid of their human neighbors.

One bird I never saw close-up as a child was the Canada Goose (*Branta canadensis*). These strong-flying waterfowl had been hunted to near-extinction in many areas, and if present they were almost out of sight as they flew high overhead, pushed by a storm front toward their distant and remote nesting grounds. These were magnificent creatures of the wilderness, many breeding far up in northern Canada, even beyond the Arctic Circle.

Then, things began to change. In 1962, a small colony of the *Giant* (sometimes called *Common*) subspecies (previously thought to be extinct) settled in ponds in the Rochester, Minnesota area (home of the Mayo Clinic). Protected from their natural predators (mostly foxes and the like), colonies of birds with little fear of humans began to grow, and to spread throughout many urban and suburban areas in the United States. Soon, nonmigratory resident populations began to breed in areas (like South Carolina) far from their original nesting grounds. With protection by local residents, and a taste for the abundant grasses surrounding many public ponds, Canada Geese now greatly outnumber the Common Mallards in our neighborhoods. Adult birds vary in size and relative length of the neck (11 or more subspecies have been described in the past), but the smaller, short-necked varieties are not native to our area. Our local birds, although they may vary in size, are of the *Giant* or *Common* variety, the largest of them all. Apparently it was only when this variety had been reduced to small numbers that *faulty* genes, otherwise responsible for fear of humans when intact, allowed the surviving birds to proliferate beneath the gun-sights of a civilization that had almost destroyed them. This was a remarkable adaptation and recovery of a great American bird. The same change is now happening with the Common Raven in certain areas, likewise a creature of the wilderness but now increasingly found in suburban parking lots.

We often see low-flying, V-shaped flocks of these great birds moving to and from the several ponds in our area, honking in unison. The birds change-off in the leadership or front position in these formations, as the lead bird has to expend more exergy breaking the wind (as does the lead truck in a convoy). Males and females are very similar, although males tend to be slightly larger, and each sex has a distinctive honking voice. They may all look the same to us, but individuals recognize each other, and pairs mate for life (which can exceed 25 years). Males and females live together, all year round. The young know their parents.

The long necks of geese allow them to reach far underwater in pursuit of aquatic plants and small animals. They also feed heavily on grasses and grains when these are available.

Females lay 2-11 eggs each year. Adults are most vulnerable as they molt during a four week period preceeding the emergence of their eggs, when they cannot fly. They often group together with other families in a crèche, for mutual protection. The males join the females in actively protecting both nest and young. At the Neely Farm pond, a bonded pair of introduced Greylag Geese (*Anser anser*, European ancestor of domesticated geese) usually join in one of these crèches with at least one Canada Goose family each year. The Grelags are much more aggressive than the Canadas in protecting the young, and they have even less fear of humans! In about 2 months, the surviving young (if there are any) are ready to fly. The local domestic ducks and the wild Comon Mallards that often join them will swim near the geese, but their social interactions with them are limited.

Attitudes about the presence of Canada Geese vary greatly. Most people seem to enjoy their presence. Perhaps in part because these were so rare, I'm still amazed when I see them gliding gracefully in the pond, or flying through our neighborhood. I also find them quite peaceful and observant when approached slowly, as long as they are not threatened. Their intensive social life and family structure is also very interesting to watch. Many supportive local residents, including many enthusiastic young children, feed bread crumbs, or grains, to the geese (These tidbits are also appreciated by local fish and turtles). They put on a great show, with the more dominant clans holding the choice positions closer to the food source. The geese will usually approach you if they think you are bringing them a treat, but if you have nothing to offer they will usually back away to the far side of the pond. They have not lost all fear, with good reason. Some people, and some animals, are still dangerous to them. If you see a flock crossing the road, be careful as you approach. Just last year we had to bring a goose injured by a vehicle here to a local wildlife rescue group.

I've heard some people say that Canada Geese are not afraid of their dogs. In truth, trained dogs are used in many areas to clear ponds of Canada Geese (See www.nogeese.com, for example). I have seen some flocks leave our pond the moment that they saw an approaching dog, and others that seemed relatively tolerant of a dog's presence. Canada Geese are protected, but in many places people try to drive them away. This is usually associated with a dislike for *goose droppings*, although these are really a very good natural fertilizer (Additional information on this subject is available at http://www.lovecanadageese.com).

Wednesday, January 14, 2009 (February 2009)

The Voices of Nature

A different sound: flock of terns on the Atlantic Coast.

Recently I turned in my noisy leaf-vac for a quiet lawn rake. I was surprised- it actually took me less time to move the leaves off of the lawn, and I actually got some meaningful upper-body exercise to boot. But the greatest benefit of this change was the "quiet." I had exchanged my leaf-blowing burden for the old-fashioned joy of leaf-raking, surrounded by the many sounds of nature. Now this was something to look forward to.

We often think of a struggle between man and nature, but the real conflict in our midst is that between man-made machines and nature. Man is really part of nature. Just as our eyes are tuned to the many colors of the natural world, our ears are tuned to its many sounds, including our own voices. Yet, over the last hundred years or so we have increasingly surrounded ourselves with an army of noisy machines (dozens of them for each one of us!). As inevitable as this emergence of motors and other powered machines appears now, this really represents a recent phenomenon in a long history of relative quiet. Now we pass much of our lives within noisy vehicles on noisy highways, or in buildings or arenas with a high ambient sound level. We are subjected to, or subject ourselves to, constant background or ambiance music, as if our lives were merely playing out the themes in a motion picture or a music video. We may consume our evening meals to the accompaniment of the nightly news, punctuated by bouts of loud advertising seeking to control our attention. The noisy machines and vehicles are everywhere, flying overhead in the wildest of places, and nearby in our kitchens. We explode holiday fireworks at a decibel level that causes many dogs to go insane, and young people drive their cars around with blaring speakers, shaking the very foundations of our houses. With loud-speakers and multimedia players we continuously subject ourselves to a high volume of low-pitched or even sub-sonic (inaudible, but still damaging) sounds that can actually cause the human heart to miss its beat. Can you hear the ringing in your ears? We are literally killing off our auditory cells! Go outside on a "quiet" Sunday afternoon. You can often hear power saws, power trimmers, and leaf blowers. In the warmer months, there is almost always a lawn mower nearby, powered by gases *exploding in its cylinders*, chopping its way through someone's lawn. One simply cannot escape the machine sounds of air conditioner units and accelerating motorized vehicles. At least most of us do not need to work in loud factories, or operate jackhammers, for a living! In the middle of each night, at least, we close our doors and seek quiet and rest as we sleep.

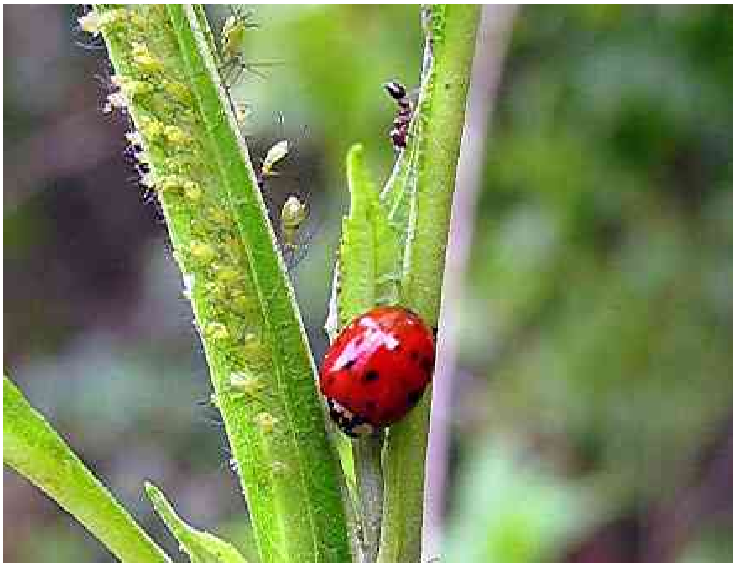
Just as we try to get away from the bright street lights to view the wonders of the starry sky, we must travel to wilder places less frequented by machines, or at least more distant from those machines. We leave our MP3 players and cell phones behind, and let our ears tune in to the many *voices of nature*. Then, and only then, we discover the world that we were meant to hear. Just as the bright stars and planets emerge in the darkened sky, so the sounds begin to appear. There is a soft wind that blows through grasses and pine-needles alike. Close your eyes- you can hear that this is not one repetitive air sound, but many sounds, more like waves breaking on a gentle shoreline. There is a rustle in the underbrush, clearly a large animal, a deer, taking flight as we approach. Winter titmice twitter and pierce us with their strident calls. A nervous squirrel chatters a warning to its neighbors, or a Blue Jay calls out the same message. Each time of day has its own distinctive sounds, culminating in the gentle rustling sounds that signify the end of day, and dusk. In season, birds, frogs, and a host of insects entertain us with their calls, both day and night. When we listen, we don't hear one repetitive call, but many, endlessly varied. We may hear the Mockingbird as it produces more than a hundred copied calls, in order. We may even hear thousands of different calls composed by a single Brown Thrasher. Or we may enjoy the more repetitive, but haunting, song of a Hermit Thrush. Listen more carefully, and it gets more interesting. The crows are calling to each other, but each call is different, distinctive as if part of a complex and mysterious language.

Looking for drama in your life? Listen to the powerful wind that signals the oncoming rain. Hear distant thunder, growing slowly but surely, until it is breaking all around us. Each downpour is an orchestra in itself, with rhythmic cycles of light and heavy rain, coming and going. First, rain grows louder but hits only the upper tree leaves. As it continues, rain begins to spill to the lower leaves and then falls heavily to the ground. Finally, we hear only the dripping, as a quiet rumble of thunder disappears in the distance. As the sun comes out, the birds begin to sing, perhaps in celebration of the rain and its passing. For a gentle and varied sound that can drown out all of your cares, listen to the sound of water as it journeys, pouring and splashing over the bedrock in Rocky Creek. For an even stronger message from eternity itself, drive down to Folly Beach or Hunting Island, and listen as an endless parade of waves, born of storms as far away as Africa, complete their journey. No one can be unmoved by this experience. It is beyond words.

So, there is noise, far too much of it. But there is also sound, sound that we were meant to hear. This sound entertains, it informs, it communicates, and it settles. It comes from all parts of nature, including the many different people that we live with. If we listen, we begin to understand many things, from the pulse of the natural world and its many moods, to the beauty and deeper meaning within the voices of our neighbors. Just listen.

Sunday, February 15, 2009 (March 2009)

Lady or Cattle Rustler?


Attending ant about to attack a feeding ladybird in Neely Farm.

Not many people have been named after beetles. Recently we saw the name "Junebug" (actually a scarab beetle) in a movie by that name, associated with a thoughtful and creative portrayal of contemporary family life in North Carolina. Then there is "Ladybird" (based on a coccinellid beetle, also known as a ladybug or lady beetle), made famous by a beloved first lady from Texas, Ladybird Johnson. Quite apart from the deeds of her husband, Lyndon, Ladybird's own legacy includes a host of beautiful prairies planted with wildflowers across the state of Texas. Of course, those beautiful prairies are filled with, you guessed it, *ladybird beetles* of all colors and sizes.

Ladybird beetles are familiar to us all. One variety, the Convergent Lady Beetle (*Hippodamia convergens*) occurs naturally in the Northeast, but is collected from aggregations in California and shipped to all corners of the United States where they are sold for "pest control." Whether or not they are really effective for this purpose is another matter! There are more than 400 different species of ladybird beetles (or coccinellids) in the United States (and more than 5,000 world wide!), and most of them feed on insects, including aphids and scale insects. A few, including the "Mexican Bean Beetle," actually feed on plants, and are considered to be pests themselves. But generally, most of us are pleased at the sight of these brightly colored and attractive beetles, as they scuttle to and fro. Children invariably love them. An old nursery rhyme of unknown origin begins with the phrase "Ladybug! Ladybug! Fly away home." We also consider the sight of a ladybird to bring "good luck." Did you ever make a wish as you blew away a ladybug, or sent it on its way?

Except for ferocious and painful fire ants, army ants, or driver ants (if you live in the tropics), we can admire the industry and selflessness of ants as a group. In the classic tale of the ant and grasshopper, it is the untiring industry of the ant that we hold in esteem. It is the lazy and self-indulgent grasshopper that lives only for today. On every continent and in almost every place where plants occur, ants of many different species gently tend a variety of plant-sucking insects, including many different aphids and scale insects. They protect these "ant cattle" or "herds" from all dangers, even at the cost of their own lives. In return, these cattle release droplets of sweet nectar for the ants to consume. If you find a cluster of aphids on a plant in Neely Farm, chances are that it will be tended by a group of ants from a nearby colony. Like ourselves, the tending ants are cooperative and communicative members of a larger community, performing only one of its many specialized tasks, within an essentially agrarian economy. They too live in organized and complex cities.

Here's where those attractive ladybird beetles come into the picture. They fly to a plant where these cattle are grazing, and immediately begin to *devour* them. Unchecked, they bring carnage to each peaceful pasturage as they visit, chewing up hundreds of grazing aphids, of all ages. The steadfast ants, of course, resist. They try to bite at the attackers, but the beetles pull in their antennae and clamp down against the plant to hold their ground as long as possible. The hard, smooth shell of each beetle is almost impossible for defending ants to grasp, but eventually the ants may prevail in driving away the ladybird, as it flies off to attack another herd. So now we can understand why ladybirds have such a wonderfully round and smooth shell. But what about that bright color (usually orange), and the spotted patterns that immediately bring them to our attention? Their color has no impact on ants, but it does advertise the presence of danger to birds and lizards, large and hungry creatures that might otherwise attack our ladybirds. In fact, red and orange are the most widely used warning colors in nature. The blood of ladybird beetles is laced with potent toxins, including many alkaloids. When attacked, some also release a quite unpleasant scent. So this beautiful jewel is actually a vial of poison!

In the balance, are these ladybirds good or bad? Are they really ladies after all (*just cleaning up the garden*, if you please), or are they *cattle rustlers*? To my mind, science doesn't answer *any* moral questions of this kind (some scientists think that it does!). The wolf brings down a young caribou, but that doesn't make the fierce wolf "bad" and the hapless caribou "good." At one time in history (or prehistory), powerful lions were among our deadliest enemies. In some places, they still are. Not too long ago, one young male African Lion (just like the one in our Greenville Zoo) tracked back and forth across a large river as it killed more than a hundred villagers, before it was finally killed. Even that kind of thing didn't make this lion "bad" to our "good." We have developed powerful weapons that clearly make us the deadly enemy of the lions. Now, in places like South Carolina, they are no more. Just a few hundred years ago, they were top predators here. I don't think this fact makes our own kind "bad," either. Like the steadfast ants, we can struggle against our own natural enemies (of which there are many), and we can even learn to avoid *self-righteous judgement* while doing so. Perhaps this ability, after all, represents the unique morality of which humankind is capable.

Friday, March 13, 2009 (April 2009)

Nomads All?

Whirlpool Galaxy, M51 (courtesy NASA).

We all move from place to place, and concepts of space and time are deeply embedded in our consciousness. We discern a difference between sitting still, and moving. We order events according to an internal time clock. We recognize relative directions and positions in space, based on an internal gauge of *up and down*, and a separate compass of *left and right*. To these we add our perception of distance (*forward and backward*), to complete a three dimensional model of space. If you studied solid geometry (Cartesian or Euclidean) in high school, then this much should be quite familiar.

At the time of the Renaissance, the emergence of *experimental physics* began to shatter this simple view. Galileo, and others, began to challenge the view that the surface of the Earth was fixed in space, and replaced this with the concept of a rotating Earth, moving rapidly around the sun in a yearly orbit. Rather than standing still, we were moving toward the east on a rotating globe at the phenomenal speed of 1,000 miles per hour. In addition, we were moving with the Earth about the sun at an even greater speed of 1,000,000 miles per day (about 40,000 miles per hour!).

Scientists were faced with an enormous challenge: How can you tell if you are really moving, and how much? Is it possible to "stand still" ? The answer, presented by Newton and others in the 1600's, was that all motion is relative, and you cannot tell if you are really moving or not. The concepts of "standing still" and "absolute motion" could not be supported. You can measure your speed *relative* to something else, but not by itself! Up until the early twentieth century, however, physicists held on to the notion that space was at least subject to the constraints of our familiar solid geometry. There was still a single time clock, ticking off the time for the entire universe.

Einstein, remarkably working ouside of the constraints of academia, began to change this view in 1905. His vision was so radical that it was barely accepted by physicists at that time, and it was never recognized with a Nobel prize! In his *special relativity*, Einstein took apart the separate concepts of space and time, and replaced these with a new concept called "four dimensional space time." Without going into the mathematical details of space time (which can actually be understood at the level of high school algebra), suffice it to say that there are no absolute distances in space, and no absolute intervals (between events) in time. Einstein allowed, however, for the existence of absolute distances between events in *space-time*. In many respects, the change was so great that even general courses in Physics, and modern astronomy programs on television, fail to present it clearly. I will present here just one statement that should highlight just how strange this *space-time* really is: The distance between the event where a photon (light particle) is emitted by an electron is a star in the Andromeda Galaxy (2,000,000 light years away), and the event where this photon reacts with a pigment in the retina of your own eye as you gaze at the heavens (2,000,000 years later), is exactly 0 (zero!) in space-time. The view that light (or a photon) moves at a constant 186,000 miles per second in space and time, and the view that light does not move at all in either space or time, are actually equivalent! For Einstein, this was only the beginning.

Einstein worked many years to reconcile the concept of gravity with this new space-time, and emerged, in the 1914-1915 time frame, with what is now rightfully viewed as the most amazing intellectual leap of the 20th century. And, once again, no Nobel prize! Here the mathematics is a bit more complex (generally beyond the undergraduate level), but the essential insight and concept is straightforward: Space-time is not a simple geometry, but one that permits straight lines to be curved. A satellite moving in orbit around the Earth appears to be pulled toward the Earth by a "force" of gravity, but it is really moving in a "straight" line in curved space time. There have been several attempts to graphically depict this on public television programs, but I think that they all fall short, or are even misleading. Our conscious mind is better geared to the perception of three-dimensional space (including what we think are straight lines), and we generally cannot visualize the curved matrix of Einstein's four-dimensional space-time.

Later in the early 20th century, a fellow named Edwin Hubble discovered that the visible "universe" was much more than the local Milky Way galaxy, and that space itself was expanding at an incredible velocity (a rate of expansion now thought to be accelerating). We learned that we are moving, with our entire solar system, around our local galaxy at several 100,000 miles per hour. In addition, our entire galaxy is moving relative to other galaxies at even greater velocities.

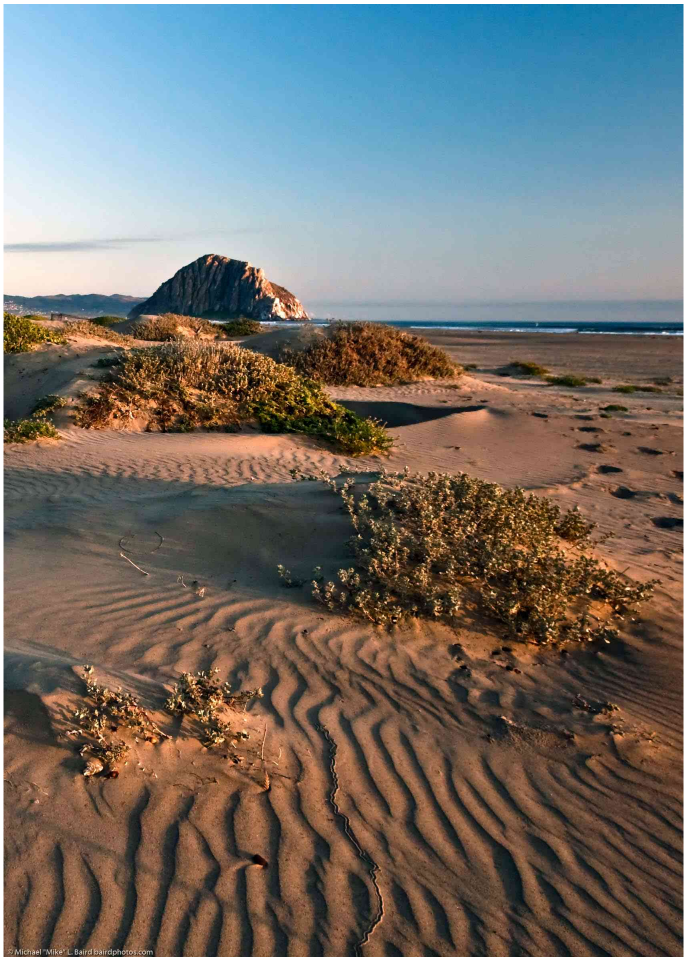
Add up all of this movement: It's an incredible journey! Remember old adage that "you can't cross the same river twice."

With our first travel to the moon and back, a haunting portrait of the Earth in space emerged. This was the "blue planet" vision. Since then, there have been many programs depicting the possibility of space travel. Indeed, one recent program hyped this as something necessary for the survival of the human race. I think that this vision represents an unfortunate, and quite unrealistic view, of our situation. We cannot simply junk this planet, and then move on to the next one when it becomes toxic. Studies of nearby planets have shown us just how unique the Earth is, and just how much we, and all other life-forms, are bound to it in a common destiny. Space beyond our atmosphere is an incredibly dangerous place. So, perhaps we are all nomads in space, but the Earth is our life-support system on that journey.

Wednesday, April 22, 2009 (May 2009)

Natural Order

There is *order* and there is *disorder*. In a well-planned and well-ordered house, each thing has its place, carefully selected to optimize either its appearance or its utility. We carefully roll up the cord for the vacumn cleaner, and place it back into its ordained position, at the right front corner of the utility closet. When we venture out-of-doors, we bring this sense of order with us. We plant a row of shrubs along a border, each identical to the next, each carefully cultivated, weeded, and trimmed to match the geometry of the formation that we have selected. We carefully select the location of each tree, to give it its own spacing and territory according to variety, in the master architectural plan for our property. We carefully tend the grassy lawn, by keeping the height close to some ideal level related to the settings on our lawn mower, and by eradicating a host of invasive species that were not part of the plan. When we grow our food, we carefully space out the placement of each genetically-identical seed in long rows, within furrows of a specified depth. This is the kind of order that we bring to the natural world: an organization of things, planned in advance by our intelligence, and laid out according to that plan. This is the kind of order that finds its ultimate expression in the elaborate and microscopic design of a computer chip.



Ripple patterns in the sand dunes at Morro State Beach, California. The ripple patterns emerged from the interaction of a myriad of individual sand grains with the wind in the Earth's gravitational field. Morro Rock is in the background. Photo courtesy of Michael L. Baird, used subject to Creative Commons Attribution 2.0 Generic license.

We also find obvious patterns in nature, far from our own designs. In the mature woodland, the trees are somehow spaced out. In the creek bottom, the various gravels are neatly sorted out in places, and sometimes the grains of sand are lined up in long ripple marks, with a regularity that we could never acheive through our own effort. At times we can see this kind of ripple mark high up in the sky, highlighted by long, parallel lines of condensing clouds, associated with the streaming rivers of the atmosphere. Then, when we look at the pattern of plant life in a mature woodland understory, we can see a familiar and even comforting combination of *order* and *disorder* (or randomness) in the layout of rocks, herbs, shrubs, and trees within a complex community of living things. We get a sense that this does not represent our *human order*, but something else, something more subtle, less predictable, and something ultimately more comforting. In these places, we may lose our own need to impose order, and look for something else.

The gardener knows the full spectrum, from the formal planting to the English garden with its delightful variety, and finally to the natural succession of plants in a natural landscape. The Japanese garden is perhaps the most ordered of all, yet strives to copy the nuance of nature at the same time, often in miniature. Then, there is the weed, that omnipresent weed that never appeared in the gardener's design. Where did it come from, and why is it here?

Nature works differently, and the difference is simply this: Whereas *human order* is based on top-down decisions, driven by an engineer or designer who plans the layout of all of the parts, a *natural order* emerges from a host of separate, bottom-up processes, each contributing to the whole. Nature operates in a manner that we can compare to our ideals for *laizzez-faire* capitalism: Every person can make his or her own decision, and the net result will be a kind of efficient order for all. At least that is the ideal! Where the trees in an orchard are carefully selected and laid out according to the plan of a horticulturalist, each of the trees in a natural woodland is the result of a separate history of events, related to the growth, transport, survival, and rooting of each single seed. In the course of this history, each of the myriad of individual processes in a natural setting *interacts with* a wide range of other processes, ranging from the condensation of a single molecule of water, to the breakdown of a small grain of sand, or the capture of atmospheric nitrogen by a single soil bacterium. Nature works this way, all the way down to the finest molecular details. What we observe as a single grand and glorious thunderstorm involves the cumulative histories of a myriad of water molecules, including at least one from every person who ever lived on this planet. If you traced the journey of but one of these molecules, it would travel through every continent, through every ocean, through every kind of creature on this planet, many times in succession. Yet, within the context of its own history, this molecule appears over and over again as a component within a larger pattern of events.

So, back to that *weed* one more time. From the perspective of natural order, it is not a weed at all. It's presence is the culmination of the innumerable actions of things both living and not-living, over a long history reaching back in time further than we can imagine. In its details, it is remarkable, even beautiful. Let us rejoice one more time in the natural order of things!

Wednesday, May 13, 2009 – (June 2009)

That Mysterious Third Eye

Photo of large adult male Green Iguana (*Iguana iguana*) from Costa Rica, courtesy of Scott Robinson. Use subject to a Creative Commons Attribution 2.0 Generic license.

You have probably heard about the *third eye*. Is this just the subject of science fiction, or does it represent some kind of mysterious extrasensory or telepathic capability?

Last month we were out to our local Greenville Zoo, watching the remarkably tame Rhinoceros Iguana that has lived there for the last year. This lizard was clearly hand-reared. A young lad casually asked me if the lizard had ears, and I said, "Yes- you can even see their ear drums!" He was surprised by this response. Lizards can hear? I went on to explain how we also had ear drums like that, hidden away at the end of auditory canals. Of course, I explained, that was why children were always taught not to put things into their ears. Then I mentioned that mysterious *third eye*, clearly visible at the top of the lizard's head, facing upward, just between the two main eyes. By this time the youngster was obviously overloaded with these strange new ideas, and his scepticism was evident as he walked away to look at some nearby snakes.

I first observed the third eye of a pet Green Iguana many years ago as a young, school-age person. Our local Carolina Anolis lizards are related, and they also have a visible *third eye* that can be seen if you look closely. But, is this really an eye? Yes! It actually has a transparent corneal lens that can be seen from the outside, nervous connections to brain (with at least two types of nerve cells or *neurons*), and a retina containing light-sensitive *cone* cells, just like those of the other eyes. There is actually a small central opening in the skull, the *pineal foramen*, through which nerve fibers can pass to the brain. So we can say with some assurance that this really is a kind of eye, and it is also light sensitive (a kind of *light meter*). With relatively few cells, however, it probably cannot form an image.

In lizards this eye is thought to have as many as three different functions. One would be to elicit a sudden flight response if a predator appeared overhead, blocking out the light. A second would involve the regulation of *circadian* (daily) cycles of behavior or physiology, keyed to the availability of light and day length. And a third function would be to measure and regulate how much the lizard exposes itself to solar radiation, for purposes of vitamin production from ultraviolet light, or to help the lizard regulate its body temperature. To date, the best evidence supports a role in circadian regulation of body temperature.

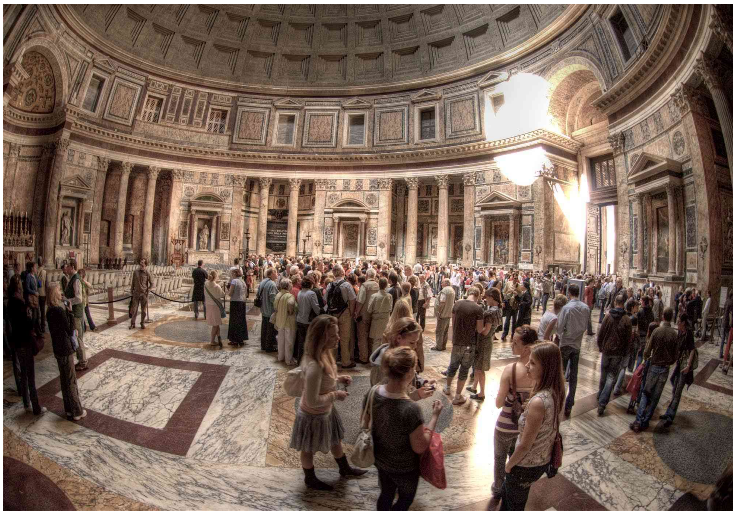
We saw how the external ear drum (or *tympanum*) of the lizard corresponded to our own internalized ear drum, but what about this third eye? This also leads us to a tale of internalization. If we look more closely at the structure of the lizard's third eye, we can describe it as a *parietal-pineal complex*, involving a close coupling of the parietal eye structure with a *pineal organ*. The pineal organ contains primarily *secretory* photoreceptor cells (If this sounds a bit like medical school, just be patient!). In other words, it secretes hormones in response to light. We clearly do not have the external parietal eye like our lizard friends, but we do have, right in the center at the base of our cerebrum, a small, pea-sized (8 mm), *pineal body*. Unlike the lizard with its parietal eye, light-meter information is relayed from our two *main eyes* to the pineal body.

The functions of our pineal body are the subjects of active research, they are somewhat complex, and to be completely honest about the subject, little understood. As late as the 20th century, many scientists actually thought that this small organ was *vestigial*. We now know that the pineal body produces more of the hormone *melatonin* when we are subjected to darkness, and that it is the only known source of this hormone in our bodies. It fact, the pineal body may actually grow in size during periods of prolonged darkness. This organ assists in the regulation of many other cyclic (daily, monthly, or seasonal) cycles, including hormonal processes associated with the onset of adolescence (inhibited by higher levels of darkness-induced melatonin), and even the estrus cycle. Children exposed to long hours of "daylight" (or artificial light) may have a lower level of melatonin production, and may, as a result, mature at an earlier age. We now know that the pineal body also plays an important role in the regulation of daily sleep cycles, and should begin to appreciate the degree to which exposure to artificial lighting interferes with the normal regulation of these cycles.

One thing is certain: Whether visible at the top of a lizard's head, or buried deep at the base of our brain, this third eye is indeed responsive to light, and it plays an important role in the regulation of cyclic or periodic activity. We are only beginning to unravel its many mysteries.

Wednesday, June 3, 2009 (July/August 2009)

Biology as Destiny



Crowd of visitors inside the Roman Pantheon in Rome, Italy. The people who visit today are different from the Roman slaves who built this enduring monument, but they are very closely related to them. Photo courtesy of Ville Miettinen, use subject to a Creative Commons Attribution 2.0 Generic license.

There are certain hard "rules" of life that are difficult to circumvent. One is that *life exists at the expense of other life*. In other words, we live by taking molecules that we need from a pool that is shared with all other living creatures. Another rule is that *change is inevitable*. Life itself is a dynamic process of change that has been compared to a burning flame. No change, no life. Creatures of all kinds, plant and animal alike, are born, they grow, they age, they reproduce, and at some time, they die. In the midst of this ever-changing life, there is a *life cycle*, a process of *continuity* affecting all living things. Each of us carries about 30,000 pairs of genes on our 46 chromosomes, one member of each pair from each of our two parents. Everything that our billions of constituent cells can do, or can ever become, is determined by the coding on these genes. Some of these genes code for our well-being, but others code for disease and even death. Fortunately, in most cases just having one good gene in each pair will keep us healthy and alive.

Now, consider a population of about 300,000,000 people. For most of human history there has never been anywhere near as large a group of people as this on our planet, but today we can find them all within the borders of the continental United States! With 46 chromosomes per person, that makes for about 15,000,000,000 (say, 15B) different chromosomes. Of course, not all of these chromosomes are unique, but many of them are. Each time we have a child, we roll the dice and take half of the chromosomes from one parent, and combine them with half of the chromosomes of the other parent. The process is not perfect, however, and hundreds of the codes in these chromosomes do get changed or rearranged each time that they are replicated. Today we can actually count these *inter-generational* changes directly.

Here's the deal. Those chromosomes code for what we are (if we can neglect the impact of our upbringing for the time being!). As a result they play a major role in determining whether or not we are able to propagate any chromosomes past our own life span, into a new life cycle. If we can, then it is the chromosomes (not us!) that have *continuity*. Sometimes, a chromosome makes this leap many times. Other times, a chromosome never gets passed into a new cycle. This is actually a very useful process, because many of those bad chromosomes, coding for all kinds of defects, don't make it. Over time this large (remember, 15B) pool of chromosomes will change. Over 100 years, the change is significant.

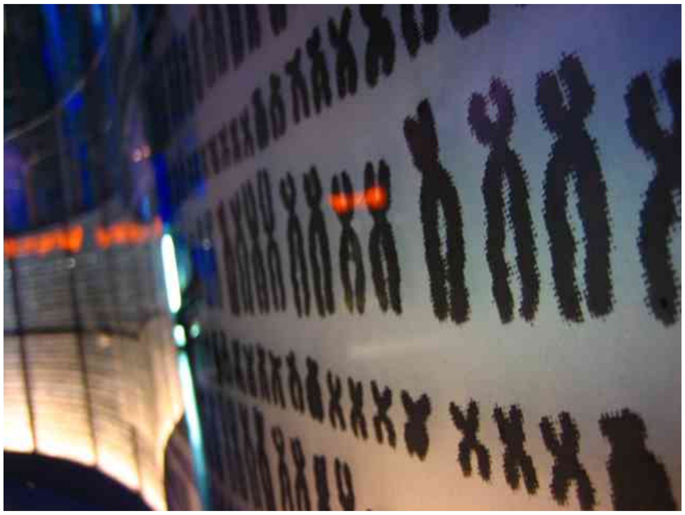
Chromosomes, then, should tend to code for features that favor their own propagation. If not, they tend to disappear. Just what features, or traits, favor the propagation of chromosomes is not always easy to identify. For example, we now know that we are attracted to people who release *different* organic chemicals from their skin. There is something to that old phrase, "It's just chemistry," after all! But how does this help chromosomes to propagate themselves? The answer appears to lie in the fact that, in the long run, *new combinations* of chromosomes (and genes) favor our ability to survive and reproduce. This may be analogous to the manner in which those societies that experimented with new technologies several hundred years ago came to dominate the world scene with superior weapons and production systems. We are still locked into this technology race, with no end in sight.

Other traits more obviously favor the continuity of our chromosomes. We care for, and favor, biologically related individuals in our own families. From the point of view of our chromosomes, our own children have a relatively high chance of supporting their propagation. What those chromosomes may not realize, however, is that *we are very closely related to all other people*. Any two people share the great majority of their genes! You may actually be more closely related (with respect to the percent of genes shared) to a complete stranger, than you are to any of your own children. Tribal behavior (language and behavior that distinguishes between *friend* and *enemy*) may result from the fact that one's inbred tribe (over many generations) shares more genes with each member than does the tribe of the enemy. Also, if your own tribe cannot grow, then your chromosomes cannot be propagated. The very factors that bring cohesiveness to one tribe also lead the members of that tribe to compete fiercely with their enemy. This behavior, of course, is a force behind both warfare and competitive sports. Even our schools are based on competition. Has biology determined our morality, as well as our destiny?

You can decide. There have always been thinkers with messages that profoundly oppose the immediate interests of our chromosomes. These messages include *love your enemies*, *turn the other cheek*, and even that one's foes will be *members of his own household*.

Tuesday, August 18, 2009 (September 2009)

Those Colorful Bodies



Wall of Chromosomes, by Dani Lurie. Use subject to Creative Commons Attribution 2.0 Generic license.

They are the *chromosomes*, named by the German anatomist Wilhelm von Waldeyer-Hartz in 1888, after the Greek words for color (*khroma*) and body (*soma*). These carriers of our genes are really quite transparent in living cells, but they stain bright red or purple with basic dyes used to study cell structure, hence the name. Charles Darwin did not know about these. Even Gregor Mendel, the Augustinian priest who founded genetics and described the inheritance of traits in plants, did not known of them. It was not until 1953, scarcely 50 years ago, that we discovered that chromosomes carried those wonderful, double-helical molecules, DNA (deoxy-ribonucleic acid), the molecules that correspond to our genes, our basic units of heredity. You can think of your collection of DNA as a library of books, each comprised of words written with an alphabet of only four letters! Each of your cells must read this library to know what to do, and how to do it. Cells that do *different things* (like nerve cells, or white blood cells) must read *different parts* of this library, but the library is essentially the same in all of your cells that carry it (and most do). At one time, of course, there was only a single cell that carried your personal library of DNA. Then it divided into two cells.

Most of the time, chromosomes are not present in our cells. It is only when cells are preparing to divide (one into two) that they package and coil up all of their DNA into paired sets of chromosomes that can be neatly separated into two *daughter* cells. The chromosome itself is really a *coil of coils of coiled DNA* strands or helices. Imagine that you take a coiled telephone cord, and then make a larger coil of it, and then make an even larger coil with the result! Proteins hold these tightly coiled bodies together at this time. Later, after the cell has pulled apart into two cells, the coils unravel, and the fine stands of DNA open up so that they can be read by the cell, and used to guide its behavior.

Chromosomes are found in all cells of plants, animals, and fungi. They are also found in the cells of many other kinds of *eucaryotes*, that is, creatures that contain their DNA within a nucleus (or *karyon*) within each cell. I won't go into all of the details here, but it now appears that there are at least 30 other groups of living eucaryotes besides the "big three" (plants, animals, and fungi). It all seemed so simple in high school! Non-eucaryotes, like bacteria and archaea, do not have chromosomes.

So far, so good. To reproduce, a cell just has to make a copy of each chromosome, then send the original to one daughter cell, and the copy to another. Journalists often try to rouse their audience with a political issue of "when does life begin?" but to the biologist, the answer is simple. Life never ended in the first place, it just continues from one cell to each of its progeny, even between generations.

But nature has a trick in store for us. Rather than putting a single set of chromosomes into each of our cells, we get two, one from each of our two parents. But from each of our parents, who also had two complete sets of chromosomes, we only get one member of each set. And, there are 23 different chromosomes in each set, for a total of 46. This means that you may have chromosome #1 from your father's mother, as well as a #1 from your mother's mother. You may have #2 from your father's father, and #2 from your mother's father. And so on. There were 46 different, independent, "heads or tails" decisions made when your personal set of chromosomes was selected! You will get a #3 from your mother, but is it the #3 from your mother's mother, or your mother's father? That is just one of the 46 decisions to be made. You also get one more set of DNA (package #47), with the mitochondria in your cells, but there is no decision here. This always comes from your mother, never from your father.

So, if you chart your family tree, you can be related to a lot of people. How many? Well 2 parents, 4 grandparents, 8 great-grandparents, and so on. Go back 10 generations, say to the time of the Declaration of Independence (or the *Battle of the Cane Brake* here in Greenville County) and there are already more than 1,000 people in your family tree. Yet, there are really *only 47 lineages of chromosomes in your ancestry*, going back through time, one for each of your chromosomes (total 46), plus one for your mitochondria, and no more. Surprisingly, you have no biological inheritance from the great majority of people in your family tree!

That paired-chromosome trick really mixes things up, making us all combinatorially different, and making our children really different from any of their ancestors. But nature has even more tricks at play here, to mix things up. Very often, when two different chromosomes in a set are held together in a cell, part of one chromosome switches places with the corresponding part of the other chromosome! Think of snipping out a piece of that #2 chromosome from your father's father and putting a piece of that #2 from your mother's father in its place, and vice versa. Now you have a pair of #2 chromosomes unlike any carried in the cells of your parents.

But why do our cells keep mixing these genes up, in all of these ways (any many more)? Why can't they just replicate themselves cleanly from generation to generation, or produce clones? The answer is thought to be just this: *change*. Before we lived in cities and used our current technologies, we were vulnerable to any number of cabable predators, including other people, and they kept changing to get better in this contest. If we stayed the same, we would not be here. We are among *the ones who changed*. We had to get even *better*, or at least *different*. Even today, a host of viruses, bacteria, and other diverse microscopic creatures keep changing at a rapid pace, finding new ways to exploit our enormous and growing population. Change is one way that we (or our chromosomes) can stay ahead of this game. So our children are always different from us, and their children will be different from them. Our chromosomes are just one of the mechanisms that ensure that this change continues into the future, but it is a kind of change that also represents the continuity of our life.